DOCUMENT RESUME

ED 372 920 SE 054 175

AUTHOR Flewelling, Gary
TITLE Math Activities Using LogoWriter--Numbers & Operations.
INSTITUTION International Society for Technology in Education, Eugene, OR.
REPORT NO ISBN-1-56484-035-2
PUB DATE 93
NOTE 105p.; For related documents, see SE 054 176-177. The "LogoWriter" application is not included in the package and is necessary for using the disk files.
AVAILABLE FROM International Society for Technology in Education, 1787 Agate Street, Eugene, OR 97403-1923 (Package includes this book, a data disk, and a single-user site license; disks are available for the Apple, MS-DOS, and Macintosh platforms).
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Addition; *Arithmetic; *Computer Assisted Instruction; Diagrams; Division; Elementary Secondary Education; *Estimation (Mathematics); Fractions; *Geometry; *Mathematics Instruction; Multiplication; *Problem Solving; Subtraction; Visualization; Worksheets
IDENTIFIERS *Computer Integrated Instruction; Conjectures (Mathematics); *LOGO Programing Language; Mathematics Activities

ABSTRACT

This book is one in a series of teacher resource books developed to: (1) rescue students from the clutches of computers that drill and control; and (2) supply teachers with computer activities compatible with a mathematics program that emphasizes investigation, problem solving, creativity, and hypothesis making and testing. This is not a book about Logo, but about mathematics and thinking mathematically. Many chapters require no Logo skills. Each chapter may include as many as seven sections: summary box, getting started, instructions, examples, activities, key summary, and worksheets and includes appropriate grade-level designations. The chapters in this book are: (1) Counting, (2) Number Rods, (3) Counting Identical Groups, (4) Number Boards, (5) Adding and Subtracting, (6) Adding and Subtracting Larger Numbers, (7) Addition and Subtraction Facts, (8) Multiplication and Division, (9) Division on a Polygon, (10) The Number Cruncher, (11) Fraction Strips, (12) Estimation Exerciser, and (13) Approximate Numbers. Appendices include a summary of LogoWriter keys (Apple IIe/IIc, IBM, and Macintosh), a quick reference (LogoWriter Primitives and Special Words), and additional primitives for the Macintosh. (MKR)

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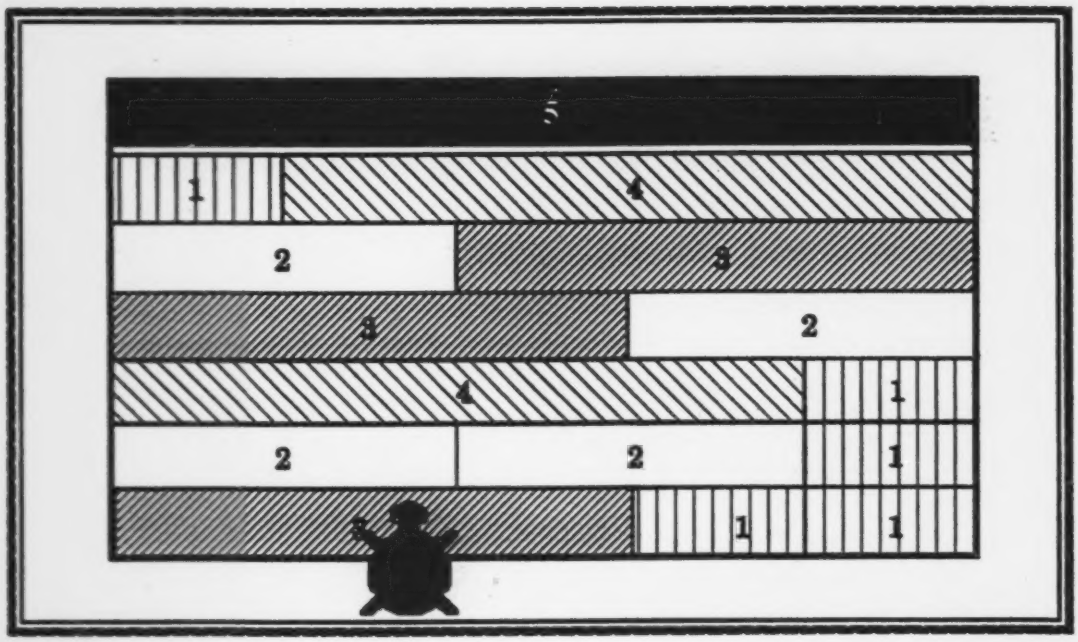
ED 372 920

Math Activities Using *LogoWriter*

Numbers & Operations



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About the Author

Gary Flewelling received his B.Sc. from the University of Windsor, Windsor, Ontario, Canada, and his M.M. (Master of Mathematics) from the University of Waterloo, Waterloo, Ontario, Canada. He has been a teacher since 1964, and a mathematics consultant for the past 13 years.

His main interests in mathematics education are natural learning and the integration of technology in the math classroom. He developed—and is still developing—*Math Activities Using LogoWriter* products and books out of a belief that computers should be used more effectively in the math classroom and that Logo should be tied more closely to the math curriculum.

Gary lives with his wife Barb in the small rural Ontario village of Arthur and spends most summers camping and rockhounding in Australia.

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© International Society for Technology in Education, 1993
1787 Agate Street, Eugene, Oregon 97403-1923
Order Desk: 800/336-5191
Phone: 503/346-4414
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CompuServe: 70014,2117
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ISBN 1-56484-035-2

Math Activities Using *LogoWriter*

Numbers & Operations

Gary Flewelling

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From the Publisher

The purchaser of the *Math Activities Using* LogoWriter—*Numbers & Operations* package receives this book, a data disk, and a single-user site license. The *LogoWriter* application is *not* included and *is* necessary for using the disk files.

The single-user site license gives the one person who is designated as the "primary user" of the package the right to make copies of worksheets, disk files, and other material necessary for use in his or her classroom; this right does not transfer to class participants. If the single-user site license is purchased by a school or school district, the intent is that one person be designated as the primary user. If several teachers will use the book, separate packages must be purchased for each individual teacher.

Acknowledgments

For my best friend, my wife Barb.

Thanks also go to Bill Higginson, Queen's University, for his encouragement; Dan Hawkins, for translating and enhancing an earlier C64 version of this chapter; Doug Benstead, Consultant, Wellington County Board of Education, for helping to "spread the word" at many computer courses and workshops; and to Linda Kennedy, for desktop publishing.

G.F.

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Preface

A working group of the Canadian Mathematics Educators Study Group (CMESG) met on the campus of the University of Waterloo in June of 1984 to discuss the issue of using Logo in schools. After three days, the group concluded that:

1. Logo, not linked strongly to existing school programs, runs the risk of becoming trivialized.
2. Logo deserves to be integrated into school math programs.
3. Logo is a tool that can be used by teachers to help them implement their mathematics curriculum.
4. Teachers need proof of items 2 and 3.
5. Proof is needed in the form of student activities illustrating items 2 and 3.
6. Samples of activities referred to in item 5 need to be developed and delivered to teachers.

The group agreed that the activities referred to in items 5 and 6 should possess many of the following characteristics.

- can be used by students with a variety of interests and abilities
- allow for a number of lines of inquiry
- can be returned to again and again throughout the school year
- can be used through the grades at varying levels of sophistication
- have links to the mathematics curriculum

- contain an element of choice/freedom/modifiability for both the teacher and the student
- may require the student to construct various procedures to carry out related investigations
- may have to be accompanied by pre-written procedures
- invite the cooperative effort of more than one participant

The conclusions and criteria listed above have guided the author throughout the development of this project.

This series of teacher resource books has been developed to meet two needs. The first, to rescue students from the clutches of computers that drill and control. The second, to supply teachers with computer activities compatible with a mathematics program that emphasizes investigation, problem solving, creativity, hypothesis making, and hypotheses testing.

It is the author's intent that the teacher review and select an appropriate chapter or set of activities within a chapter and integrate them into his or her mathematics program.

Some teachers will want to introduce the whole class to an activity. Others will want to introduce the activity to a smaller group of students who will then act as an expert group for the rest of the class. Still others will simply hand over a copy of the chapter to some students and challenge them to discover something interesting that they can share with others. Some teachers will have a student choose an activity of interest and allow the student to pursue it independently.

In all of these scenarios the teacher will act as a facilitator of the activity, encouraging students to reflect on their work, make and test conjectures, share and discuss findings and problems with other students, ask and investigate "what if" questions, evaluate and refine their own and other students' work, and do some follow-up study. Students can then report their findings in a variety of ways, for example, as a written

report, an oral report to a small group of classmates, a poster or similar display, or a set of conclusions summarized in their journal.

Introduction

This is not a book about Logo; it is a book about math and thinking mathematically. Many chapters require no Logo skills. Where Logo skills are required, they are identified. The basic Logo primitives are described in the appendix at the end of this book. This document does not teach advanced Logo programming skills. See your Logo manual for such details.

Chapter Organization

Each chapter may include as many as seven sections: summary box, getting started, instructions, examples, activities, key summary, and worksheets.

Summary Box

The summary box at the beginning of each chapter includes information about files containing accompanying procedures, appropriate grade levels, color recommendations, and exceptions regarding platform availability. Also included is an illustration of one possible pattern or design.

File Names

Most chapters are accompanied by a group of pre-written *LogoWriter* (TM by LCSI) procedures included in the file named in the summary box.

Grade Level

Many chapters in this book can be used at a variety of levels of sophistication and are identified as multigrade:

P indicates Grades 1-3

J indicates Grades 4-6

I indicates Grades 7-10

S indicates Grades 11-12

Color

Many of the programs used in this book include color. The number of colors available depends on the kind of computer you are using. In general, there are 6 colors on the Apple II, and 3 pen colors for the DOS version; the colors are limited to 15 on the Macintosh.

With a monochrome monitor, the color will alternate between black and white. In general, this will make the turtle alternate between being visible and invisible. If you can't find the turtle, press the key for pen color—usually I = Ink.

Software/Hardware

This book can be used with versions of *LogoWriter* 2.0 or above. Data disks to accompany it are available for the Apple, MS-DOS, or Macintosh platforms. Some programs are not available in all platforms; exceptions are noted in the summary box.

Getting Started

The directions in the Getting Started section of each chapter tell you how to begin using the program for that chapter.

Instructions

Most chapters include an Instructions section. In general, this section describes the details of how the program keys work. Sometimes this section includes an example, particularly when the function of the program is quite complex.

If the chapter is accompanied by pre-written procedures, instructions for using the procedures are given.

Examples

Some chapters have a number of examples that are included to show the teacher or students what the program can

create. Studying these examples will often help them understand how the program functions.

Activities

A series of suggested activities generally accompanies each chapter. Each teacher must judge the appropriateness of any activity for a particular student. Many activities progress better with two students working together.

Teachers are encouraged to take the initiative and modify activities as needed and create new activities as appropriate. They should preview each chapter before giving it to their students.

Key Summary

Most chapters include a key summary at the end. This chart can be copied and kept near the computers where students are working. Details of the key functions are *not* included here.

Worksheets

Some chapters include worksheets. Their purpose is outlined in the appropriate suggested activities.

Tips for Using These Programs

Before You Begin

Make a copy of the disk that came with this book. Store the original in a safe place.

Start *LogoWriter* in the usual manner. If the chapter requires use of a set of pre-written procedures, locate the appropriate file name on the copy of the disk that came with this book. Load the file into *LogoWriter*.

Be sure that the Shapes page that comes with the data disk is also on the disk containing the LogoWriter *files.*

Space

After working with some programs for a length of time, you could get an "out of space" message. If that happens, generally you can start the program again by typing START in the Command Center.

Interrupting a Program

At any time you may interrupt a program that is running by pressing the stop key (Command-. on the Mac; Ctrl-Break for Dos; Apple-S for Apple).

Working With Pictures

Students often will want to save designs that they have made. The following procedure will work for most of the programs in this book. Notes about working with retrieved pictures for particular programs are found in the individual chapters.

To Save a Picture

1. The program should not be running; if necessary, press the Q key or the stop key to exit. You need to be able to enter commands directly in the Command Center.
2. Type SETDISK "A and press Return/Enter.
3. Insert a disk in the A or first drive.
4. Type SAVEPIC "*name of picture*" and press Return/Enter.

To Retrieve a Picture

1. The program should not be running; if necessary, press the Q key or the stop key to exit. You need to be able to enter commands directly in the Command Center.
2. Type SETDISK "A and press Return/Enter.
3. Insert a disk in the A or first drive.
4. Type LOADPIC "*name of picture*" and press Return/Enter.

Printing

Printing the Page

Some of the programs that come with this book include single-keystroke commands for printing the page. If there are no built-in commands for printing, you can exit the program and type

```
PRINTSCREEN
```

to transfer the graphics and text on the page to paper.

Printing Procedures

If you want a copy of the procedures for any particular program, you can flip the page, move the cursor to the Command Center (use the down key), and type

```
PRINTTEXT
```

The procedures will appear on paper the same way that they appear on the screen.

Note that the code for all of the files is not documented and in general should not be provided to students.

Chapter 1. Counting

Filename: COUNT

Grade Level: P/J
Color: Optional

The COUNT program allows students to produce a large display of whole numbers (to a maximum of 999) on a monitor in a student or teacher specified sequence.

The number displays are an excellent accompaniment to activities related to counting sequences, both forward and backward, recording of numbers, and counting when skipping a fixed increment.

Getting Started

1. Get the page COUNT.
2. Type START and press Return/Enter.

3. Enter two numbers when prompted. The first number is the number to begin the counting sequence. The second number is the second number in the counting sequence.

   The difference between the second number and the first number is the increment used to determine the rest of the numbers in the sequence.

4. At the > prompt in the Command Center, use the following keys to display numbers on the page.

Instructions

Displaying a Number (N Key)

Press the N key to see a number. Each time the N key is pressed, the next number in the sequence is displayed. If the number becomes greater than 999, the number is reset to the first number in the counting sequence.

Restarting the Count (R Key)

Pressing the R key starts the count again at the first number entered. The increment is unchanged.

Altering the Sequence (A Key)

When the A key is pressed, the user is asked to enter the next number in the sequence starting at the currently displayed number. That is, if 50 is displayed, then an entry of 49 causes the sequence 49, 48, 47, ... to be displayed when the N key is pressed repeatedly. If instead a 55 were entered, then the sequence would be 55, 60, 65, ...

Quitting the Program (Q Key)

Pressing the Q key quits the COUNT program. Type START and press Return/Enter to begin again.

Activities

Activity 1: Simple Counting

Use the program to practice counting. For simple counting, enter 1 as the first number and 2 as the second.

Activity 2: Counting by Increments

Practice counting by increments. For example, to count by fives, enter 1 as the first number and 6 as the second number (6 - 1 = 5).

Activity 3: Add by Counting

With first number 1 and second number 2, count one set of objects. Then count from this number to add a second set to the first.

Activity 4: Counting Backwards

With a larger number, say 10, as first number and one less as second number, count backwards.

Activity 5: Challenges

Enter first and second numbers of your choice, press the N key three or four times and ask another student to predict the next number. Then exchange roles.

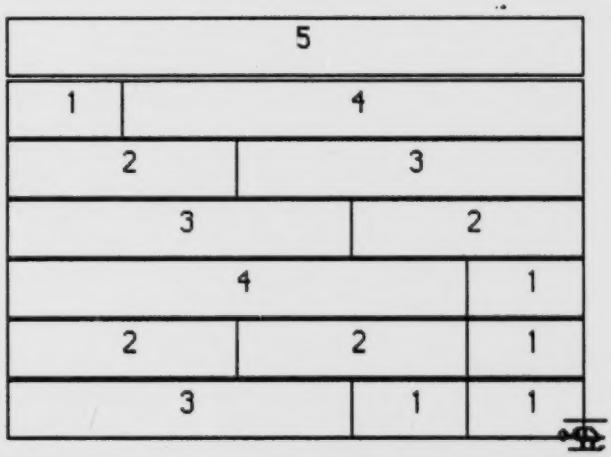
Key Summary for COUNT

N	Displays the current number
R	Resets count to first number
A	Alters the increment by allowing entry of the next number in a sequence
Q	Quits the program (Type START and press Return/Enter to begin again.)
	To print the graphics and text as they appear on the screen, quit the program, type PRINTSCREEN, and then press Return/Enter

Chapter 2. Number Rods

Filename: NUMRODS

Grade Level: P/J/I
Color: Optional



The NUMRODS page can be used somewhat like a set of electronic cuisenaire rods. Students can represent any number as a rectangular rod. Below this representation of the number, students also can draw up to six other sets of number rods and see their relationship to the original number.

Getting Started

1. Get the page NUMRODS.
2. Type START and press Return/Enter.
3. Enter a positive whole number when asked for an initial rod length. The initial rod will be shown at the top of the

page. It is used to compare against other rod combinations and cannot be erased.

4. When the > prompt appears in the Command Center, use the keys described in the following section.

   Press Return / Enter after each command.

Instructions

Entering Numbers

Enter a number that is smaller than the length of the initial rod and press Return/Enter. A rod of that length is drawn. Enter another number, and another rod is drawn to the right of the first one. Use the L key (See the instruction later in this section.) to start a new line of rods.

Note that if the helicopter disappears, it is the color of the background, and the next rod it draws will be invisible. Press Return / Enter to change the helicopter (pen) color.

Erasing a Rod (E Key)

Press the E key to erase the last rod drawn. You can erase all of the rods in one line, but you cannot erase rods in a line that is completed.

Starting a New Line of Rods (L Key)

Press the L key to start a new line of rods. You do not have to complete a line to start a new line. If the rods fill the page, all of the rods except the initial rod are erased.

Clearing the Page (K Key)

Press the K key to clear the page and begin with a new initial rod.

Quitting NUMRODS Program (Q Key)

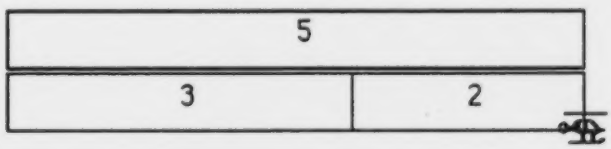
Press the Q key to quit the program. Type START and press Return/Enter to begin again.

Activities

Activity 1: Number Families

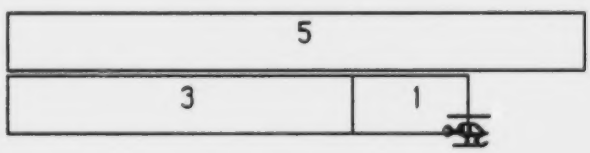
With or without cuisenaire-type counters, students can use this page to identify and record number families.

The following diagram can be recorded as 3 + 2 = 5 or 5 - 3 = 2 or 5 - 2 = 3.

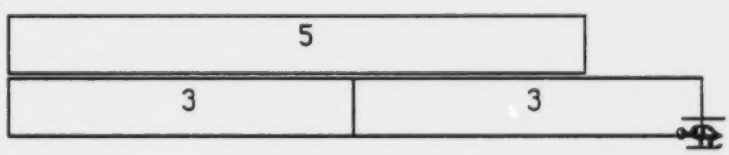


Activity 2: Comparing Numbers

Numbers can be compared. The following can be recorded as 3 + 1 < 5 or 5 > 3 + 1



while this next diagram can be recorded as 3 + 3 > 5 or 5 < 3 + 3.



Activity 3: Determining Remainders

Work in pairs. Enter one number. Your partner (with or without counters at his or her disposal) determines the remaining number, such that the two rods together are as long as the original number rod. Then switch roles.

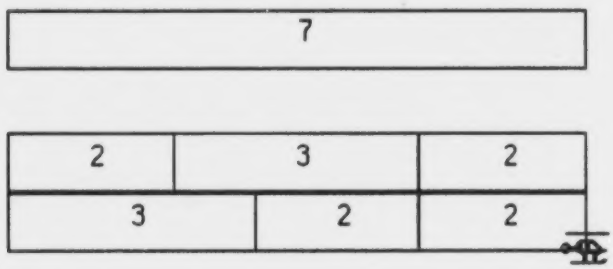
Activity 4: Investigation

How many different pairs are there for a given number? Use this program to discover the rule.

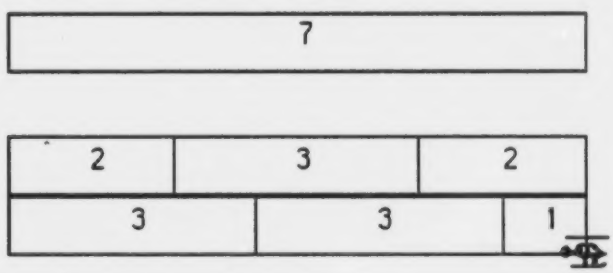
Activity 5: Different Combinations

Create a string of number rods equal to some original number. Another student creates a different string of rods where none of the cracks between the rods line up with those in your string. (See the following two examples.)

The first is an incorrect solution because the last numbers line up:



The following is a correct solution.



Activity 7: Play a NUM-type Game

Enter a number such as 21. Make a rule such as "Players cannot use a number bigger than some number, say 5." Take turns building number rods. The person making the last rod match the end of the original number rod wins (or loses depending on the rule). The teacher can adjust the rules and numbers to the players or you can make your own rules.

Key Summary for NUMRODS

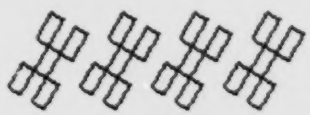
Number	Creates a rod of *number* size
E	Erases last number rod
L	Starts new line of number rods
K	Clears the page and starts over
Q	Quits the program (Type START and press Return/Enter to begin again.)
	To print the graphics and text as they appear on the screen, quit the program, type PRINTSCREEN, and then press Return/Enter

Chapter 3. Counting Identical Groups

Filename: MULT

Grade Level: P/J
Color: Optional
Not available for the Apple

4 groups of 5 = 4 X 5



With this program students can practice counting identical groups of objects. They also can calculate products from 1 x 1 to 10 x 10. The numbers are displayed as any one of three sets of rectangles. The student specifies both the number of rectangles in a set and the number of sets.

Getting Started

1. Get the page MULT.
2. Type START and press Return/Enter.
3. When prompted, enter a number between 100 and 1000. This initializes the random number generator so that the same patterns are not created each time the program is run.
4. When the "Enter-an-expression" prompt appears, use the following instructions.

Instructions

Entering Expressions

Expressions can be entered in four different ways. For example, to count eight groups of four, the student can enter, leaving spaces between symbols:

8 x 4	using "x" for multiply
8 * 4	using the calculator symbol
8 groups of 4	using words
8 g 4	using "g" for "groups of"

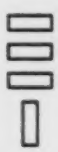
Note that the numbers in an expression must be single digits.

Once an expression is entered correctly, a > prompt appears. If an error is made in entering an expression, the Enter-an-expression prompt remains in the Command Center.

Displaying Groups (N key)

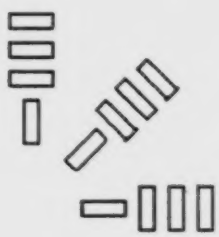
Press the N key to see the next group. For example, if eight groups of four is the expression entered, you see

1 group of 4 = 1 x 4



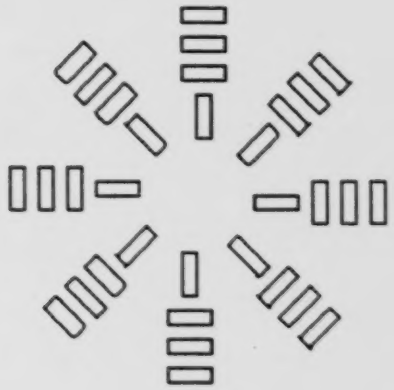
2 groups of 4 = 2 x 4

3 groups of 4 = 3 x 4



and eventually

8 groups of 4 = 8 x 4



The > prompt continues to appear until all of the groups have been drawn. When all of the groups are on the page, the Enter-an-expression prompt reappears.

Note that occasionally a display may be difficult to read.

Quitting the Program (Q Key)

To quit the program, press the Q key when the Enter-an-expression prompt is in the Command Center.

Be sure to press Return / Enter after pressing the Q key.

Activities

Activity 1: Counting

How many objects are represented by expressions from 1 group of 1 to 10 groups of 10? Use the MULT program to count the totals.

Activity 2: Multiplying

What are the values of products from 1 x 1 to 10 x 10? Use the MULT program to determine them.

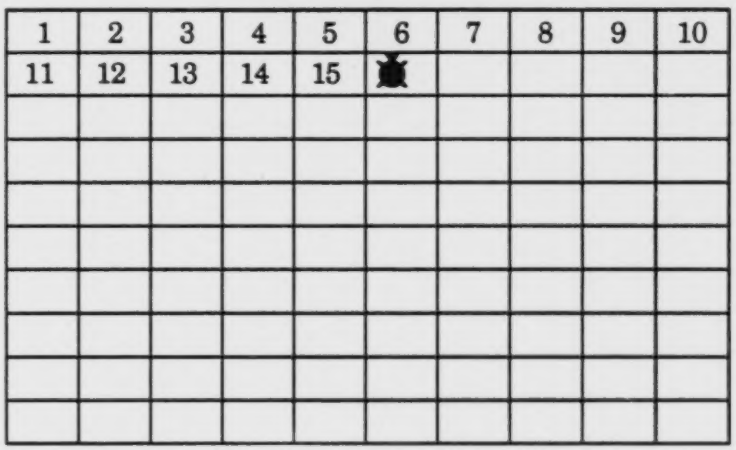
Activity 3: Verbal, Symbolic, and Geometric Representations of Numbers

You will need a supply of uniformly sized pieces of paper, say, 1 inch x 4 inches in size. First, use the MULT program to print out a variety of geometrical groups from a number of products, for example, 9 x 6, 6 x 9, 8 x 7, and 7 x 8. Now, on the small paper strips, write the numerical values of these products; one on each strip. Write the words describing these products on yet other pieces of paper. The challenge is to match numerical values with words describing the products with the drawings of the groupings created by MULT.

Chapter 4. Number Boards

Filename: NBOARD

Grade Level: P/J/I
Color: Optional



NBOARD lets students create square number boards from 3 x 3 to 4 x 4, 5 x 5, 6 x 6, or 10 x 10. The numbers placed on the board are determined by entering the values for the first and second numbers in a sequence.

Getting Started

1. Get the page NBOARD.
2. Type START and press Return/Enter.
3. When prompted with

   ```
   Enter size of a number square. (3, 4, 5, 6, or
   10):
   ```

select the size of the grid to be drawn on the page and press Return/Enter.

4. After the prompt, enter the first and second numbers in a sequence.
5. At the > prompt, use the following keys.

Instructions

Moving the Turtle (Arrow Keys)

Pressing the arrow keys moves the turtle from square to square within the grid.

Flipping a Number (F Key)

Pressing the F key causes the number to appear or disappear on the square on which the turtle is located.

Hiding the Numbers (H Key)

Pressing the H key causes all of the numbers in the grid to disappear.

Showing the Numbers (N Key)

The N key toggles all the numbers in the grid between visible and invisible. If no numbers are visible, pressing the N key causes all of the numbers in the grid to appear. If you have flipped some numbers using the F key and then press the N key, the numbers that were flipped (invisible) will appear, and those numbers that had been visible will disappear.

Quitting the Program (Q Key)

Press the Q key to quit the program. Type START and press Return/Enter to begin again with a different size grid.

Examples

Example 1

A 10 x 10 number board with first number 1 and second number 2 and the first 15 numbers displayed looks like this:

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15					

Example 2

A 10 x 10 number board, with the first number 1 and second number 3, looks like this:

1	3	5	7	9	11				

Example 3

A 10 x 10 number board with first number 100 and second number 99 looks like this:

100	99	98	97	96	95	94	93	92	91
90	89	88	87						

Note that a 10 x 10 board can be used as a hundredths, decimal, or percent board by entering 0.01 as the first number and 0.02 as the second number.

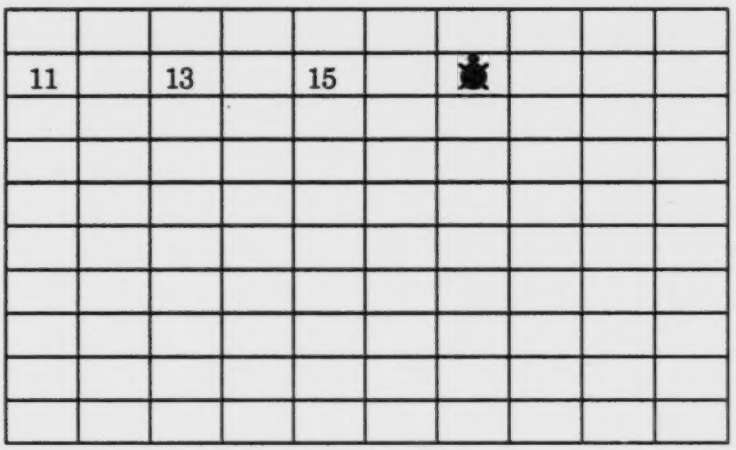
Activities

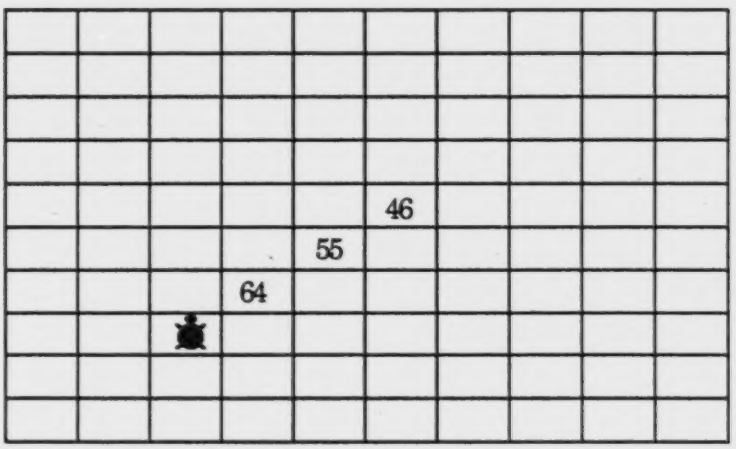
Activity 1: Exploration

Try some activities similar to those conducted with a real number board using the NBOARD program.

Activity 2: Predictions

Turn over three numbers in a line (horizontal, vertical, or diagonal). Predict the value of next number in the line, give reasons for the prediction, and then verify by flipping the number over. Play with another student. One of you flips three numbers, and the other makes a prediction.





Activity 3: Completing Number Boards

Specify a number board, partially fill it in, print it, and give it to another student to complete. Print a complete number board to use as an answer sheet.

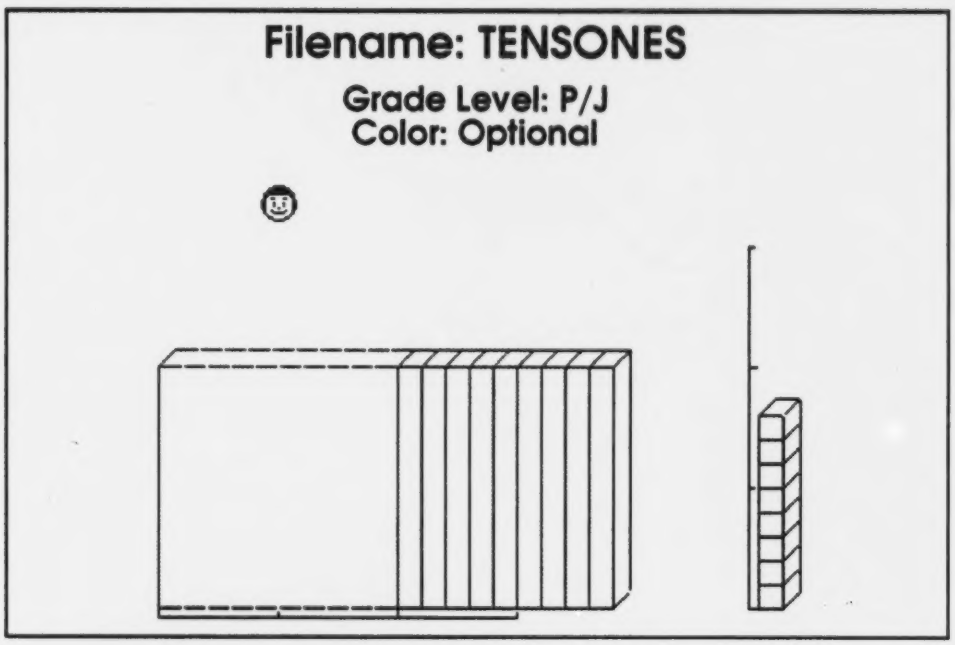
Activity 4: Search for Patterns

Turn over a geometric pattern of numbers and search for numeric patterns.

Key Summary for NBOARD

Arrow Keys	Move the turtle
F	Flips a number
H	Hides all numbers
N	Shows all numbers that are invisible
Q	Quits the program (Type START and press Return/Enter to begin again.)
	To print the graphics and text as they appear on the screen, quit the program, type PRINTSCREEN, and then press Return/Enter

Chapter 5. Adding and Subtracting



The TENSONES program lets students count forward or backward, that is, add or subtract a whole number and see the result as a display of blocks. The diagram in the summary box represents 198: one group of hundreds, nine groups of tens, and eight groups of ones.

Notice that the total entered is limited by the size of the display on the page.

Getting Started

1. Get the page TENSONES.

2. Type START and press Return/Enter.

   Two scales appear on the page. The scale on the left is for groups of tens or for a group of hundreds. The scale on the right is for ones. A smile face indicates which scale is being used to borrow or regroup.

3. At the > prompt in the Command Center, use the following keys.

Instructions

Entering Numbers and Signs

Numbers from 1 to 99 can be entered. You can precede a number with a sign or follow a number with a sign. The sign and current number are displayed in the upper left corner of the page. For example, if you enter +, you see

```
+0
```

on the page. If you then press 3, you see

```
+3
```

and if you then press 5, you see

```
+35
```

If you then press -, you see

```
-35
```

If you then press 4, you see

```
-4
```

Each time you enter a sign, the program begins entry of a new number.

Note that you do not have to press the shift key to enter the + sign.

Adding or Subtracting a Number (Space Bar)

When you press the space bar, the number that is displayed on the page is added to the current total.

Moving the Smile Face (Arrow Keys)

Pressing the right arrow key moves the smile face to the ones area of the page; pressing the left arrow key moves the smile face to the tens/hundreds area of the page.

Borrowing (B Key)

Pressing the B Key causes 10 to be borrowed when the smile face is over the tens/hundreds area of the page.

Regrouping (R Key)

Pressing the R key causes regrouping in the area under the smile face.

Changing the Color (I Key)

Pressing the I key cycles through the available pen colors. Changing the pen color can help keep track of groups added to the total.

Starting Over (K Key)

Pressing the K key clears the page of graphics and resets the total to zero. A zero is displayed on the page.

Quitting the Program (Q Key)

Pressing the Q key quits the TENSONES program. Type START and press Return/Enter to begin again.

Activities

Activity 1: Free Exploration

Spend some time learning how this program works. Try entering small numbers, then adding or subtracting.

Activity 2: Counting

Count forward (or backward) by ones, twos, and so forth.

Activity 3: Addition and Subtraction

Solve story problems using this program.

Eight white mice and seven blue mice are in a cage. How many mice are there altogether?

Press 8 + and then the space bar. Press 7 + and then the space bar. The answer is 15 ones. Regroup this to 1 group of tens and 5 ones.

There are 24 students. If 7 leave, how many are left? Press 24 + and then the space bar. Press 1 - and the space bar seven times (or press 7 - once).

The program will prompt the user to borrow when necessary.

Activity 4: Formal Addition and Subtraction

Use this program to reinforce traditional borrowing and regrouping of standard addition and subtraction problems.

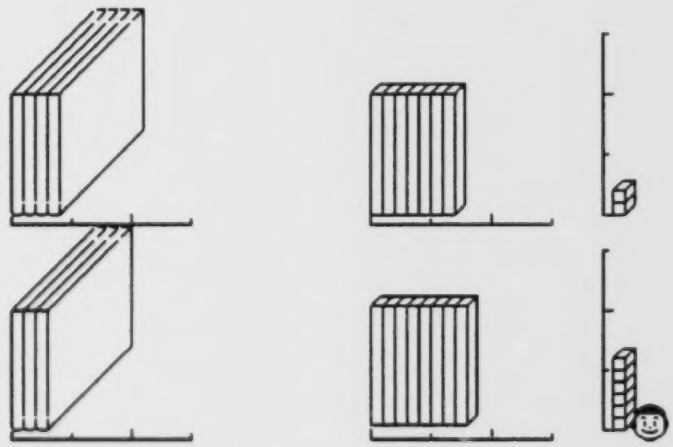
Key Summary for TENSONES

0-9, + , -	Enter numbers and signs
Space Bar	Adds or subtracts current number
Left and Right Arrow	Move smile face between ones area and tens/hundreds area
B	Borrows from tens/hundreds
R	Regroups
I	Cycles through available pen colors
K	Clears the page and sets the total to 0
Q	Quits the program (Type START and press Return/Enter to begin again.)
	To print the graphics and text as they appear on the screen, quit the program, type PRINTSCREEN, and then press Return/Enter

Chapter 6. Adding and Subtracting Larger Numbers

Filename: BASETEN

Grade Level: P/J
Color: Optional
Not available for the Apple.



The BASETEN program lets students count forward or backward, that is, add or subtract by any whole number from 1 to 999 and see the result as a display of base ten blocks. There is an upper and lower field allowing two different numbers to be displayed at one time. In the summary box, the upper display represents 472 while the lower display represents 386.

Getting Started

1. Get the page BASETEN.
2. Type START and press Return/Enter.

   Six scales appear on the page. The scales on the left are used for groups of hundreds. The scales in the middle are for groups of tens. The scales on the right are for ones. A smile face indicates which scale is being used to borrow or regroup.
3. At the > prompt in the Command Center, use the following keys.

Instructions

Entering Numbers and Signs

Numbers from 1 to 999 can be entered. You can precede a number with a sign or follow a number with a sign. The sign and current number are displayed in the upper left corner of the page. For example, if you enter +, you see

```
+0
```

on the page. If you then press 3, you see

```
+3
```

and if you then press 5, you see

```
+35
```

If you then press -, you see

```
-35
```

If you then press 4, you see

```
-4
```

Each time you enter a sign, the program begins entry of a new number.

Note that you do not have to press the shift key to enter the + sign.

Adding or Subtracting a Number (Space Bar)

When you press the space bar, the number that is displayed on the page is added to the current total.

Moving the Smile Face (Arrow Keys)

The arrow keys move the smile face among the scales on the page.

Borrowing (B Key)

Pressing the B key causes 10 to be borrowed when the smile face is above the tens/hundreds area of the page. When over the hundreds, this causes the borrowing of 10 tens; when over the tens, this causes the borrowing of 10 ones.

Regrouping (R Key)

Pressing the R key causes regrouping in the area under the smile face.

Changing the Color (I Key)

Pressing the I key cycles through the available pen colors. Changing the pen color can help keep track of groups added to the total.

Starting Over (K Key)

Pressing the K key clears the page of graphics and resets the total to zero. A zero is displayed on the page.

Quitting the Program (Q key

Pressing the Q key quits the BASETEN program. Type START and press Return/Enter to begin again.

Activities

Activity 1: Counting

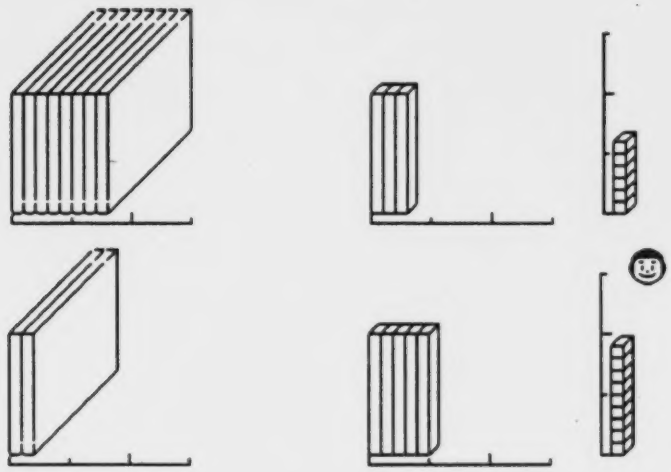
Count forward or backward by ones, twos, tens, and hundreds. Use this program to work on the concept of place value.

Activity 2: Addition and Subtraction

Use this program to illustrate addition and subtraction story problems and generate answers.

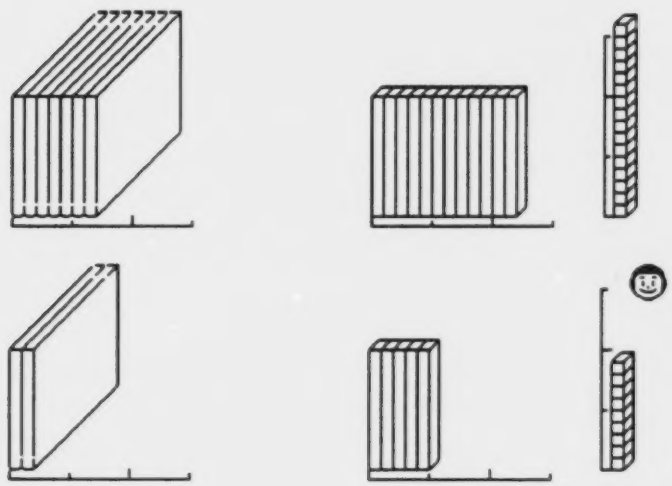
For example, of 836 people in a school, 259 watched the races. How many did not watch the races?

Set up the problem:



Borrow to allow subtraction. Here 1 group of hundreds was borrowed, giving 13 groups of tens; and then 1 group of tens was borrowed, giving 16 ones.

Notice that this borrowing need not be done in the "conventional" manner.



The subtraction could then be carried out by subtracting 9 ones from 13 ones, 5 tens from 12 tens, and 2 hundreds from 7 hundreds, or all at once.

Activity 3: Verify Addition and Subtraction

Complete addition and subtraction story problems away from the computer. Verify the answers using the BASETEN program.

Activity 4: Formal Methods of Addition and Subtraction

Use this program to reinforce traditional borrowing and regrouping of standard addition and subtraction problems.

Key Summary for BASETEN

0-9, + , -	Enter numbers and signs
Space Bar	Adds or subtracts current number
Arrow Keys	Move smile face among scales on the page
B	Borrows
R	Regroups
I	Cycles through the available pen colors
K	Clears the page and sets the total to 0
Q	Quits the program (Type START and press Return/Enter to begin again.)
	To print the graphics and text as they appear on the screen, quit the program, type PRINTSCREEN, and then press Return/Enter

Chapter 7. Addition and Subtraction Facts

Filename: ADDSUB

Grade Level: P
Color: Recommended

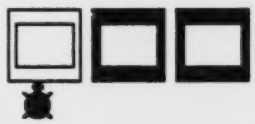
The ADDSUB program allows students to practice subtraction facts.

Sets of from 1 to 18 objects can be displayed. The objects appear as a set of identical squares. The squares removed or subtracted are one color. The number of squares entered as remaining in the set are colored a second color. The number of squares of the first color plus the number of squares of the second color can range over all addition facts from 1 + 1 to 9 + 9.

Getting Started

1. Get the page ADDSUB.
2. Type START and press Return/Enter.
3. At the prompt, enter a number from 2 to 18. Teachers might want to use this feature to encourage practice of particular subtraction facts.

Three windows are then displayed, with the turtle sitting under the first window.

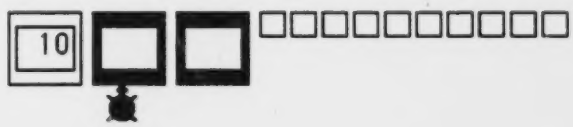


Note that if you are using a monochrome monitor, the middle window will fill with black, and the first and the last windows will both fill with white.

Instructions

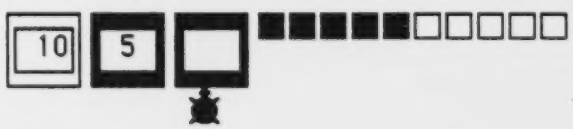
Using the First Window

The first window on the left holds the number representing the number of objects to be worked with. If the student presses Return/Enter, the number entered when the program starts appears. If the student enters a number from 2 to 18 and presses Return/Enter, that number will appear in the window. For example entering a 10 will display



Using the Middle Window

The middle window displays the number of objects being subtracted. If the student presses Return/Enter, a randomly selected number from 1 to 9 will be displayed. If the student enters a number from 1 to 9 and presses Return/Enter, then that number will be displayed in the window and the same number of squares is colored to match the window.

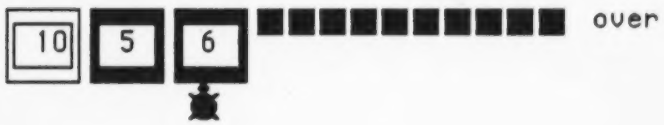


Using the Last Window

The last window displays the number remaining. If the student presses Return/Enter, the correct number remaining is displayed in the window and the rest of the squares are colored to match the last window.

The student also can enter any number from 1 to 9 and press Return/Enter. If the number is too small, the student will see that one or more of the remaining squares will not be colored.

If the number entered is too large, the student will see that the remaining squares are colored and the word "over" is displayed.



Printing the Page (P Key)

Press the P key and then press Return/Enter to print the page.

Clearing the Page (K Key)

Press the K key and then press Return/Enter to clear any windows and boxes from the page. The initial three windows reappear with the turtle under the first box.

Note that after you have completed four problems, the screen is full. Press Return/Enter, and the screen will automatically clear. The initial three windows then reappear.

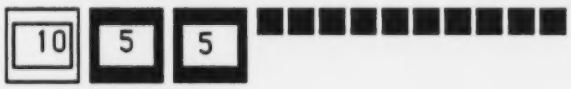
Quitting the Program (Q Key)

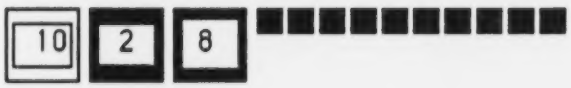
Press the Q key and then press Return/Enter to quit the ADDSUB program. Type START and press Return/Enter to begin again.

Activities

Activity 1: Fact Families

For a fixed number, identify the related subtraction and addition facts, for example, 10 - 1 = 9, 10 - 2 = 8, 10 - 3 = 7, and so on. Print your page and add appropriate plus, minus, and equal signs.





Activity 2: Grab Bag

Put a set of from 1 to 18 counters in a bag and enter the number of counters in the first window. Have another student remove some of the counters from the bag and enter this number in the middle window. Have a third student determine the number of counters left in the bag, without reaching into or looking into the bag, and enter this number in the last window. Empty the bag and verify the third student's answer. Switch roles and play again.

Activity 3: Story Problems

With the subtraction word problems provided, use this program to solve each problem.

Activity 4: Student Pairs

Enter a number from 2 to 18. Your partner enters a number from 1 to 9 to be subtracted. Enter the difference. Switch roles.

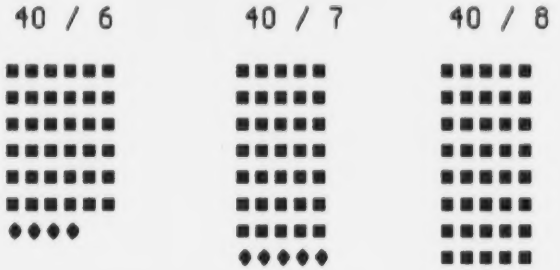
Key Summary for ADDSUB

Number Keys	Enter numbers in windows
P	Prints the page
K	Clears the page and sets the total to 0
Q	Quits the program (Type START and press Return/Enter to begin again.)
	To print the graphics and text as they appear on the screen, quit the program, type PRINTSCREEN, and then press Return/Enter

Chapter 8. Multiplication and Division

Filename: MATH

Grade Level: P/J
Color: Optional



This chapter includes four separate programs, COUNTER, MULTIPLY, DIVIDE, and NUMBER, for practicing multiplication and division facts. Each program is described separately.

COUNTER

COUNTER allows students to enter a number to count by and an upper limit for the counting. A table of all positive whole numbers from 1 to the upper limit then appears with the appropriate numbers starred.

For example, if the user types

```
COUNTER
```

presses the Return/Enter key, and then asks to count by twos to 50, the first 50 whole numbers are displayed with stars by the multiples of two.

```
1   2*  3   4*  5   6*  7   8*  9   10*
11  12* 13  14* 15  16* 17  18* 19  20*
21  22* 23  24* 25  26* 27  28* 29  30*
31  32* 33  34* 35  36* 37  38* 39  40*
41  42* 43  44* 45  46* 47  48* 49  50*
```

Note that the upper limit displayed will always be the next lowest 10 (e.g., if "count to?" is 49, COUNTER displays and counts to 40).

Press the Q key to quit the program.

MULTIPLY

The MULTIPLY program allows students to enter a multiplication expression. The product is displayed as an array of small squares. To start the program, the user types `MULTIPLY` and presses the Return/Enter key. For example, 7 x 4, 4 x 7, and 5 x 7 are displayed as follows.

Note that for some combinations of larger numbers the display wraps. Press the Q key, type `MULTIPLY` to restart, and try a different problem.

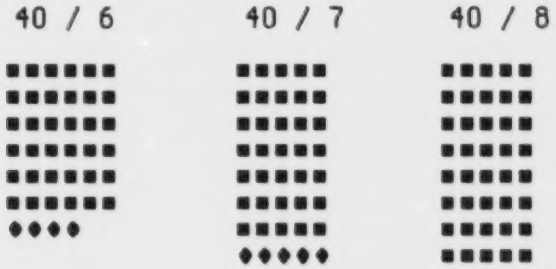
Press the Q key to quit the program.

DIVIDE

DIVIDE asks students to enter a division problem. To start the program, the user types `DIVIDE` and presses the Return/Enter key. The student is prompted to enter the dividend and then the divisor. The quotient and remainder are displayed as an array of small squares.

In the following example, 40 / 6, 40 / 7, and 40 / 8 are displayed.

Note that the remainders are represented by small diamonds of a different color.



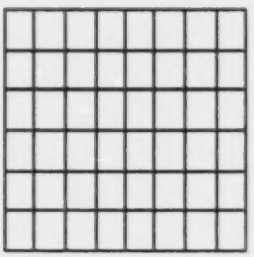
Note that for some combinations of larger numbers the display wraps. Press the Q key, type `DIVIDE` *to restart, and try a different problem.*

Press the Q key to quit the program.

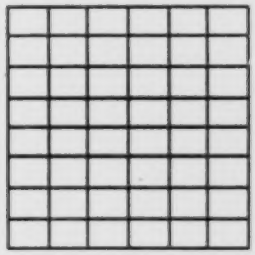
NUMBER

NUMBER allows students to enter a number <100. To start the program, the user types `NUMBER` and presses the Return/Enter key. After entering a number, each time Return/Enter is pressed, the number is depicted as a rectangle divided into smaller rectangles that represent the factors of the number. *No factor may be >10.*

In the following example, 48 is shown represented by a grid of rectangles that is six rows long and eight columns wide.



If the user presses Return/Enter again, the product 6 x 8 is shown as a rectangle that is eight rows high by six columns wide.



There are no more factor pairs that are <10, so no more factors will be displayed.

Press the Q key to quit the program.

Activities

Activity 1: Counter

Look for patterns to aid in learning multiplication facts. For example, in multiples of 9 the digits of the products add up to 9, the tens digits increase by 1, and the ones digits decrease by 1.

Activity 2: Multiply

Use MULTIPLY as an aid in solving multiplication story problems. The displays can be used to identify corresponding division statements.

Activity 3: Divide

Use this program as an aid in solving division story problems. The displays can be used to identify corresponding multiplication statements.

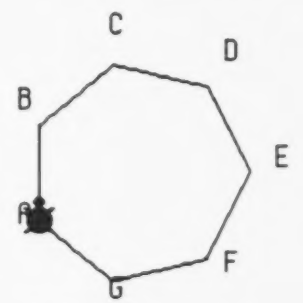
Activity 4: Number

Use NUMBER to verify factor pairs identified by students.

Chapter 9. Division on a Polygon

Filename: SHORTDIV

Grade Level: P/J/I
Color: Optional



The SHORTDIV program asks students to enter a dividend and a divisor. The turtle then draws a polygon with the number of sides equal to the divisor. When the user again presses Return/Enter, the turtle moves around the polygon passing over the same number of edges as the number representing the dividend. The number of times the turtle goes around the polygon (the quotient) is displayed.

Getting Started

1. Get the page SHORTDIV.
2. Type START and press Return/Enter.
3. Enter the dividend and divisor at the prompts.

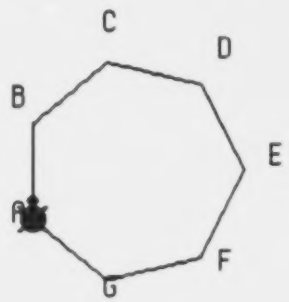
If the divisor is 10 or less, a labeled polygon is drawn. If the divisor is 11 or larger, a dot is placed at the turtle's starting point and a polygon with an appropriate number of sides is drawn.

Note that a large number for a divisor produces a polygon that looks like a circle.

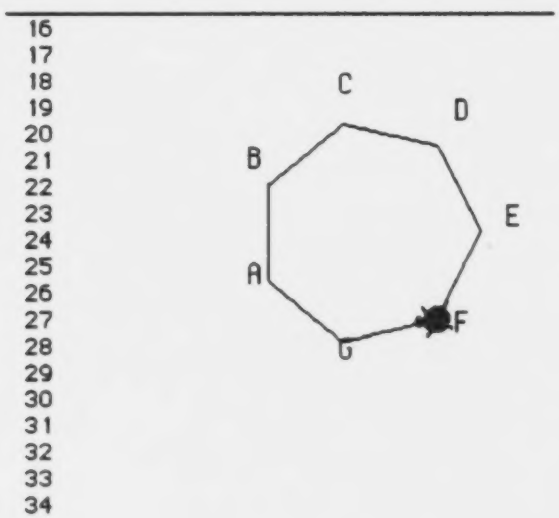
The turtle draws the polygon.

4. At the prompt, press Return/Enter. The turtle then retraces the polygon. Each time the polygon is retraced, the count is recorded on the left side of the page.

For example, 243 divided by 7 gives



Pressing Return/Enter makes the turtle go around the polygon to retrace 243 sides of the seven-sided polygon.



The student can observe the number of trips or cycles the turtle makes around the polygon and the vertex at which it stops. The number of cycles corresponds to the quotient. The distance (number of sides) the turtle stops beyond its starting point corresponds to the remainder.

Instructions

Entering the Dividend and Divisor

The user is prompted to enter a dividend and a divisor, following each with pressing the Return/Enter key.

Clearing the Screen (K Key)

Pressing the K key followed by Return/Enter clears the screen and allows you to begin again.

Quitting the Program (Q Key)

Press the Q key and then press Return/Enter to quit the SHORTDIV program. Type START and press Return/Enter to begin again.

Activities

Activity 1: Long Division

Work out division problems, such as 85 divided by 6, using pencil and paper. Before the problem is entered, use the results of the calculations to predict the number of cycles that the turtle will make around the polygon and its ending position.

Two students could independently work on the same questions, entering the corresponding number commands into the computer and predicting number of cycles and the turtle's ending position.

Activity 2: Short Division

Repeat Activity 1 using short instead of long division.

Activity 3: Mental Math

Repeat Activity 1 doing all arithmetic without paper or pencil.

Activity 4: Two Digit Division

Restrict the dividend to three or four digits, for example 147 divided by 27 or 2042 divided by 86. Repeat Activity 1. Notice the circle-like nature of polygons with more than 10 sides. You must estimate the stopping position on the polygon.

Activity 5: Estimating Quotients

Repeat Activity 4 but estimate the quotient and ignore the remainder.

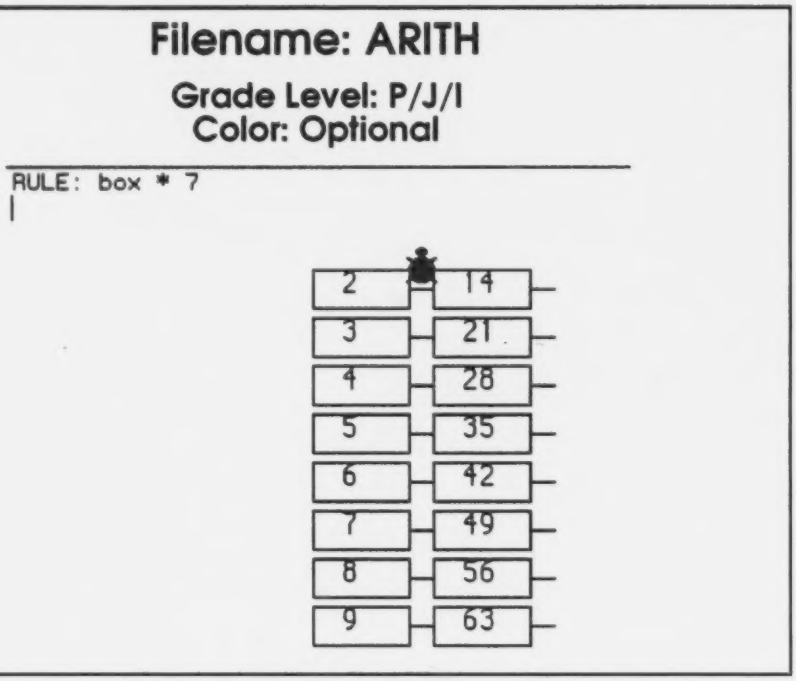
Key Summary for SHORTDIV

0-9	Enter dividends and divisors
K	Clears the page
Q	Quits the program (Type START and press Return/Enter to begin again.)
	To print the graphics and text as they appear on the screen, quit the program, type PRINTSCREEN, and then press Return/Enter

Chapter 10. The Number Cruncher

Filename: ARITH

Grade Level: P/J/I
Color: Optional



The ARITH program lets students practice a variety of arithmetic skills.

There are a number of components to this program. Students can work with conventional arithmetic operations or work with the sum of the digits of answers.

The student or teacher inputs up to eight different numbers (seven on the Apple). These numbers are then operated on by a rule specified by the user. The user can enter answers or get correct answers directly from the computer. The answer set itself can then be used as a new set of numbers on which

to apply the same arithmetic rule or some new arithmetic rule of the student's or teacher's choosing.

Getting Started

1. Get the page ARITH.
2. Type START and press Return/Enter.
3. At the prompt, enter the format for the answer. The possibilities include the following.

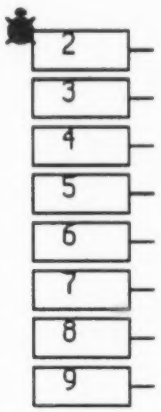
   - **Normal Format.** Numbers are entered and displayed in whole number or decimal format; for example, the answer to 4 * 6 should be entered as 24.
   - **Remainder Format.** Use this format for whole number division resulting in a whole number remainder. For example, the answer to the division problem 34 / 5 should be entered as 6R4.

     Do not put spaces on either side of the R when using this format.
   - **Modulus Format.** With this format, the user enters a positive whole number as the modulus. The correct answers entered in the table are the remainders from dividing the dividend by the modulus. For example, if you enter a modulus of 4, then 11 / 4 = 2R3 and 7 / 4 = 1R3. The correct answer entered for both is 3, because 11 and 7 are equivalent "modulo 4." This format can be used to work with large numbers.
   - **Sum-of-Digits Format.** In this format, only the sum of the digits of the answer is entered or displayed. For example, the answer to 4 * 6 would be entered as 6 because 4 * 6 = 24 and 2 + 4 = 6. The answer to 12 + 9 would be entered as 3 because 12 + 9 = 21 and 2 + 1 = 3.

4. At the prompt, enter eight numbers to work with (seven on the Apple). Type all of the numbers on one line, separated by spaces. For example, if the user enters

   2 3 4 5 6 7 8 9

   the following is displayed on the page.



5. Manipulate these numbers using the keys described in the following section.

   Note that if more than eight numbers are entered, the display does not appear. If the user then enters eight or fewer numbers, the display is confusing. If this happens, press the K key and Return / Enter to clear the display.

Instructions

Defining a Rule (R Key)

Press the R key to define a rule or expression to apply to the numbers in the boxes. You may enter numbers, B for box, an operation symbol (+, -, *, /), or brackets. Press Return/Enter after each symbol. The rule to date is displayed in the upper left corner of the page. When the rule is complete, press the F key.

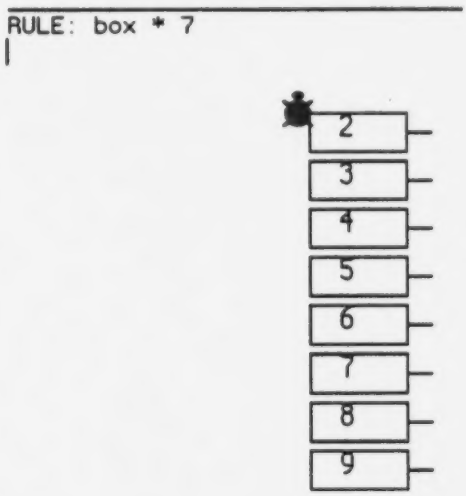
Note that "box" must be part of the rule. That is

* 7

for the rule will result in an error. The correct rule might be

```
box * 7.
```

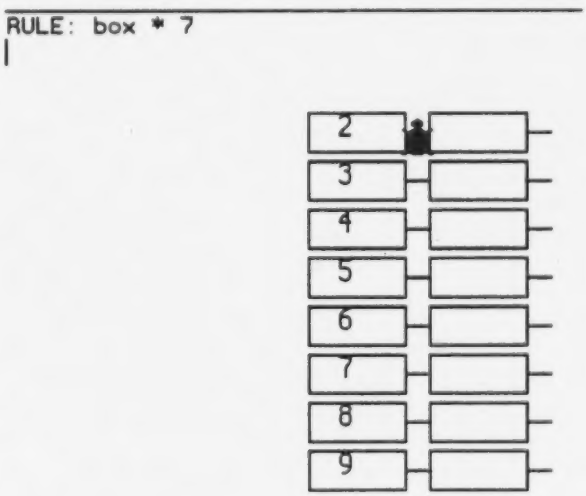
This rule says "Take the number in the box and multiply it by 7."



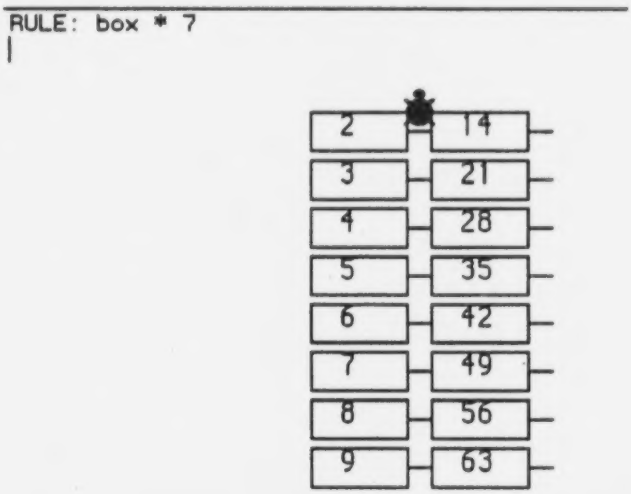
Also note that a rule with only box in it may be defined.

Entering the Answers (A Key)

With a rule defined, the user presses the A key to switch to the answer mode.

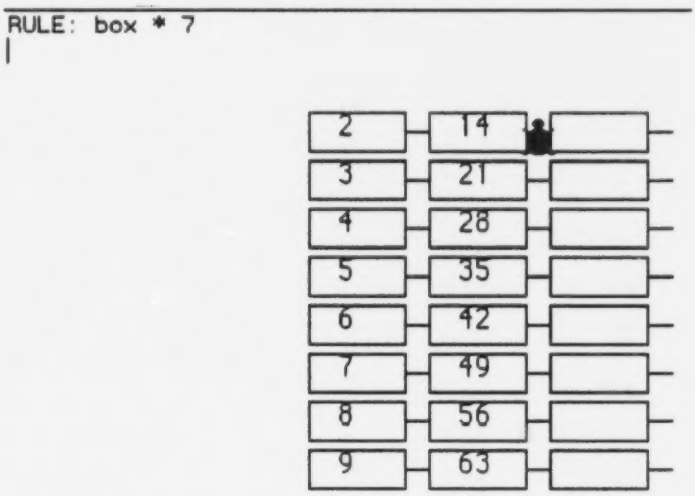


The user may enter the answer or press Return/Enter to see the correct answer. If the user enters an incorrect answer, it will not displayed.



When answers are being entered, other key options are not available. After the user applies the rule to all of the boxed numbers, the keys described in this section are again available.

Once a set of answers is complete, the A key can be pressed again. Then apply the rule to the first answer set (middle column) and generate a new answer set in the third column.



More Space (S Key)

Pressing the S key clears the screen, displaying only the last column of numbers. This allows the rule to be applied over and over to new sets of answers.

Clearing the Page (K Key)

The K key clears the page of all calculations and displays the original set of numbers.

A New Set of Numbers (N Key)

This option allows a new set of numbers to be entered.

Printing the Page (P Key)

Pressing the P key allows the user to print the page currently displayed.

Quitting the Program (Q Key)

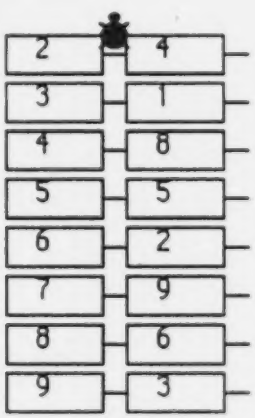
Pressing the Q key quits the program. Type START and press Return/Enter to begin again.

Examples

Example 1

Multiply by 7, answer in mod 10 format.

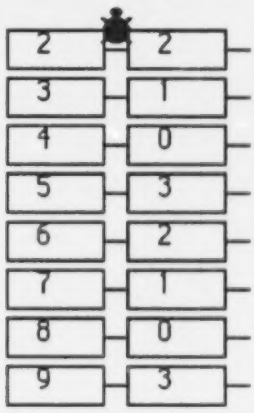
```
RULE: box * 7
```



Example 2

Multiply by 7, answer in mod 4 format.

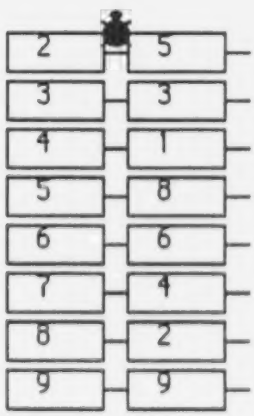
```
RULE: box * 7
```



Example 3

Multiply by 7, answer in sum-of-digits format.

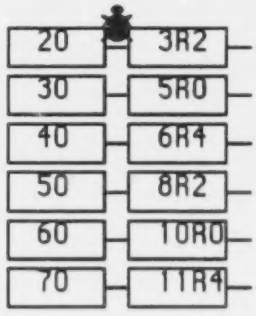
```
RULE: box * 7
```



Example 4

Divide by 6, answer in remainder format.

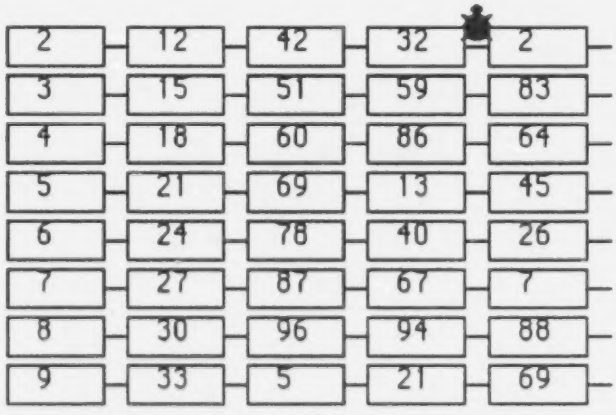
```
RULE: box / 6
|
```



Example 5

Add 2 and multiply the answer by 3, answer in mod 100 format.

```
RULE: ( box + 2 ) * 3
```



Notice that the third column is obtained by applying the rule to the numbers in the second column. The mod 100 format is ignored if the answer is <100.

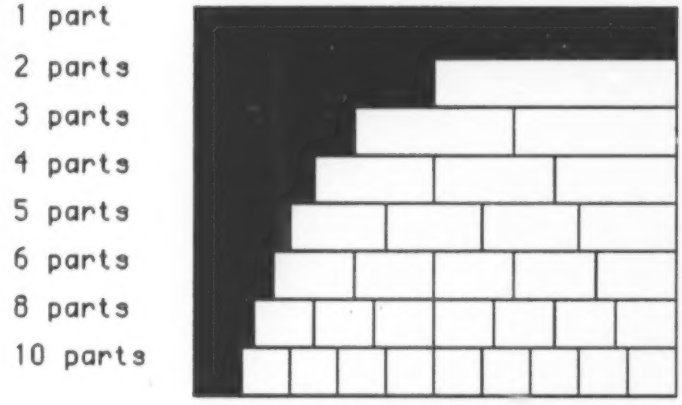
Key Summary for ARITH

R	Defines a rule, an expression, for manipulating the last column of boxes using numbers, B, operation signs (+ - * /), and brackets. (Press the F key when you have finished defining your rule.)
A	Switches to answer mode; enter answers or see answers displayed
S	Clears the page and displays the last set of answers
K	Clears the page and displays the original set of numbers
N	Enters a new set of numbers
P	Prints the page
Q	Quits the program (Type START and press Return/Enter to begin again.)

Chapter 11. Fraction Strips

Filename: PARTS

Grade Level: P/J/I
Color: Recommended



The PARTS program allows students to quickly represent a large variety of fractions, including decimals and percents, as fraction strips.

This chapter can be used to teach fractions, decimal and percent concepts, compare fractions, establish the meaning of equivalent fractions, estimate fractional values, identify properties of fractions, establish rules for the adding and subtracting of fractions, and practice estimating the decimal and percent values of proper fractions.

Getting Started

1. Get the page PARTS.
2. Type START and press Return/Enter.

3. After a one-part fraction bar appears at the top of the page and a > prompt appears in the Command Center, use the keys described in the following section.

Instructions

Entering Fractional Parts (Number Keys)

When a number is entered at the > prompt, a fraction bar with that number of parts is drawn. The arrow-cursor must be to the left of the fraction strips to enter numbers.

Note that when the page is full of fraction strips, no more numbers will be accepted.

Moving the Cursor (Arrow Keys)

The arrow keys move the arrow-cursor. If the cursor is over a part of a fraction, that part can be filled or unfilled. If the cursor is to the left of a fraction strip, a number can be entered to draw a new fraction strip.

Filling a Part (F Key)

When the arrow-cursor is above a part of a fraction strip, pressing the F key causes that part to fill with the current color.

Unfilling a Part (U Key)

When the arrow-cursor is above a part of a fraction strip, pressing the U key removes the color from that part of the fraction strip.

Note that if you fill with black and your lines are black, unfill will cause everything, including the lines, to be erased. Because distinguishing "pen color" from "fill color" is difficult on a monochrome monitor, you may not wish to use the U Key in black and white.

To use unfill, fill with a color other than black.

Changing the Color (I Key)

Pressing the I key cycles through the available colors. The arrow-cursor indicates the current color.

Note that on monochrome screens, the color alternates between black and white. When the cursor matches the background it will not be visible.

Erasing a Strip (E Key)

Pressing the E key erases the last fraction strip that was drawn. Use the arrow keys to position the cursor next to the strip that you want to erase, and press the E key and Return/Enter.

The E key cannot be used to erase the one-part strip.

Clearing the Page (K Key)

Pressing the K key removes all of the fraction strips from the page and starts over with a fraction bar with one part.

Quitting the Program (Q Key)

Pressing the Q key quits the program. Type START and press Return/Enter to begin again.

Activities

Activity 1: Make a Fraction

Draw and color specific fractions.

Activity 2: Comparing Fractions

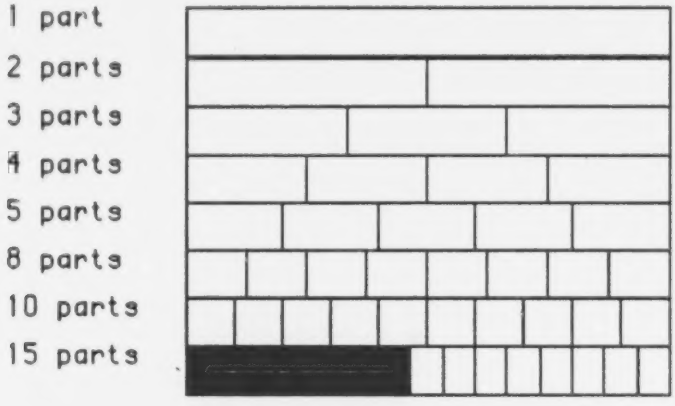
Place several familiar fractions on the page. For example, use denominators 2, 3, 4, 5, 6, 8, and 10. Use them to find fractions that are equal and nearly equal.

Activity 3: Equivalent Fractions

Find a set of equivalent fractions for a given fraction.

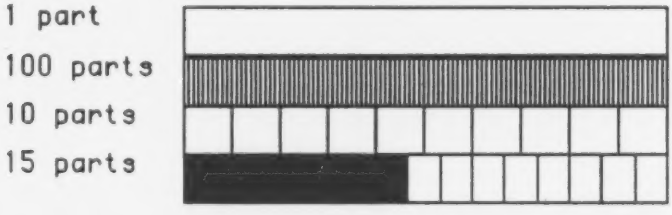
Activity 4: Estimating Fractions

Place some familiar fraction, for example, fractions with denominators 2, 3, 4, 5, 6, 8, and 10, on the page. Given any other fraction, for example 7/15, draw and color it and then find familiar fractions that are close in value to 7/15. This activity can be conducted as a competition between two students.



Activity 5: Estimating Decimal Values

Place 10- and 100-part fraction strips on the page. Place a given fraction, such as 7/15, on the screen and estimate its decimal value.

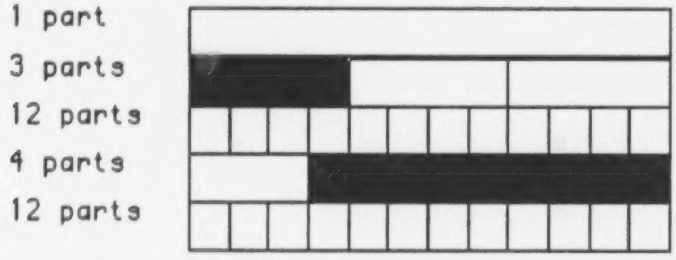


Activity 6: Estimating Percents

Repeat Activity 5 only use the 10- and 100-part strips to estimate the percent value of a given fraction.

Activity 7: Fraction Addition/Subtraction

Use fraction strips to demonstrate the sum or difference of two fractions. The following example pertains to examination of 1/3 and 3/4.



Activity 8. Properties of Fractions

Put the seven strips, 2, 3, 4, 5, 6, 8, and 10, on the page and look for patterns. For example, when numerators are one (or in general, equal), the bigger the denominator the smaller the fraction.

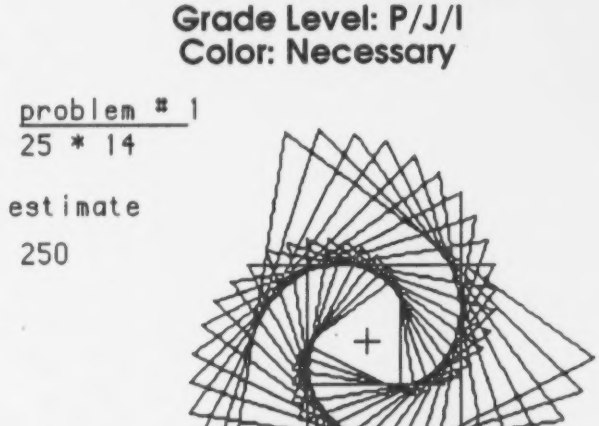
Key Summary for PARTS

Number Keys	Draw a fraction strip with the number of parts entered
Arrow Keys	Move the arrow-cursor for filling and unfilling parts or adding fraction strips
F	Fills a part of a fraction strip
U	Unfills a part of a fraction strip
I	Cycles through the available pen colors
E	Erases a fraction strip
K	Clears the page and begins again
Q	Quits the program (Type START and press Return/Enter to begin again.)
	To print the graphics and text as they appear on the screen, quit the program, type PRINTSCREEN, and then press Return/Enter

Chapter 12. Estimation Exerciser

Filename: ESTIMATE

Grade Level: P/J/I
Color: Necessary



The ESTIMATE program lets students practice the very important skill of estimating answers. The teacher or students can enter a set of arithmetic expressions and then enter estimates for the answers to those problems.

Getting Started

1. Get the page ESTIMATE.
2. Type START and press Return/Enter.
3. Enter a sequence of questions one at a time, pressing F when finished with the entire set. Each question is

assigned a question number. Each question can be entered as a number or a numerical expression, but Logo format must be used. For example,

- 6 multiplied by 0.12 is entered as 6 * 0.12
- 10 divided by 0.125 is entered as 10 / 0.125
- the sum of 430, 27, and 950 is entered as 430 + 27 + 950
- the average of 12 and 18 is entered as (12 + 18) / 2

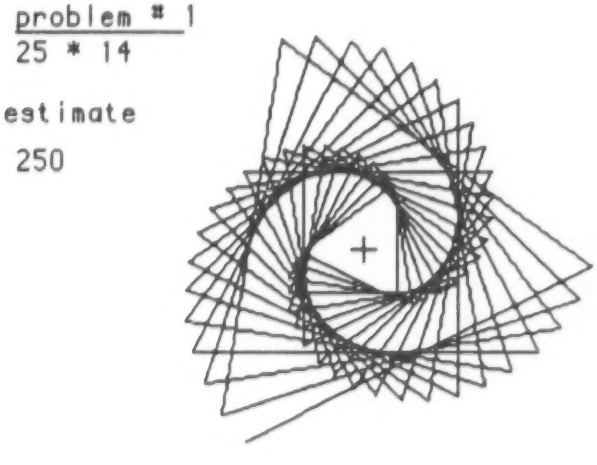
Note that more advanced functions can be used as well. See your LogoWriter manual to find out which functions are available in your version.

4. After pressing the F key, a > prompt appears in the Command Center; enter an estimate for the first expression and press Return/Enter. Use the keys described in the following section.

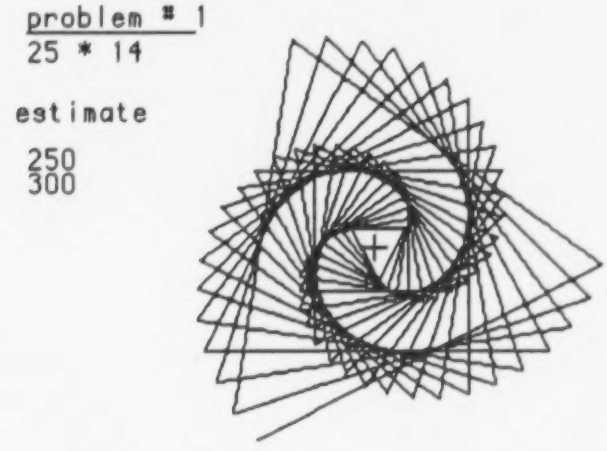
Instructions

Entering Estimates

The computer displays the problem and the estimate on the monitor and draws a partial inward spiral.



The better the estimate, the closer the spiral approaches the spot on the screen marked with a "+."



The background color also changes as the estimates improve. If the estimate is close to the correct answer, a message is briefly displayed. If the exact answer is entered, a message indicates that the answer is correct.

Note that if a worse estimate is given, the spiral is not redrawn. Thus the best estimate so far is shown by the drawing while the color changes still indicate how close or far away the estimate is.

Next Question (N Key)

At any point in the estimation process, the user may move to the next question by pressing the N key. If the N key is pressed after the last question, the program recycles to the first question.

Restarting the Question Sequence (R Key)

To return to the first question, press the R key.

Clearing the Graphics (K Key)

Press the K key to remove graphics from the page.

Quitting the Program (Q Key)

Press the Q key to quit the program. Type START and press Return/Enter to begin again.

Activities

Activity 1: Estimation Practice

Enter a number of arithmetic expressions at one time. Alone, or with a partner, work your way through the set of estimation questions. Alternate turns making estimates for a particular problem.

Activity 2: Real-World Problems

Use the restaurant menu provided to select an order, and then use the program to get an estimate of the bill. Similar real-world tasks could be used with the program.

Key Summary for ESTIMATE

Number Keys	Enter estimates
N	Moves to the next question in the list of entered questions
R	Returns to the first question
K	Clears the graphics from the page
Q	Quits the program (Type START and press Return/Enter to begin again.)

Chapter 13. Approximate Numbers

Filename: APPROX

Grade Level: I
Color: Optional

Problem: A 1 21 * 24

```
21.4 * 24.5 = 524.3
21.0 * 23.5 = 493.5
20.7 * 24.2 = 500.94
21.4 * 24.4 = 522.16
20.7 * 24.1 = 498.87
21.1 * 23.7 = 500.07
20.8 * 23.5 = 488.8
21.1 * 24.1 = 508.51
21.5 * 23.7 = 509.55
21.0 * 24.4 = 512.4
21.5 * 24.3 = 522.45
20.9 * 23.6 = 493.24
20.5 * 24.5 = 502.25
21.0 * 24.3 = 510.3
```

This chapter lets students describe the accuracy of each number in an arithmetic expression and then output any number of possible values for the numbers in the expression, along with the value of the expression itself.

Suppose, for example, that a student measures the dimensions of a rectangle to the nearest centimeter and uses these dimensions to calculate the area of the rectangle. If the dimensions of the rectangle are recorded as 5 cm x 4 cm, the measurements could be as small as 4.5 cm x 3.5 cm for a smallest area of 13.75 square centimeters and as large as 5.5 cm x 4.5 cm for a largest area of 24.75 square centimeters. APPROX calculates the area of the rectangle and prints

possible dimensions and answers in the range of answers from 13.75 to 24.75.

This problem would be entered as:

```
A 1 5 * 4
```

"A 1" tells the computer that the numbers that follow are all accurate to the nearest unit, here 1 cm. The computer will generate sample rectangle measurements and their areas. For example,

```
4.9 * 3.5 = 17.15
4.9 * 4.0 = 19.6
5.4 * 4.4 = 23.76
4.6 * 4.3 = 19.78
4.7 * 4.2 = 19.74
5.3 * 4.4 = 23.32
4.8 * 4.0 = 19.2
5.4 * 3.9 = 21.06
4.8 * 4.3 = 20.64
4.5 * 3.5 = 15.75
4.8 * 4.4 = 21.12
5.4 * 4.5 = 24.3
5.2 * 4.4 = 22.88
4.9 * 4.5 = 22.05
```

Getting Started

1. Get the page APPROX.
2. Type START and press Return/Enter.
3. At the prompt, enter a problem following the instructions in the next section.

Instructions

Format of the Problems

- Each problem must start with an A (for approximate) or an E (for exact) for the form of the number(s) you want to use in the problem to follow.

  If an A is entered, then a number indicating the level of accuracy must follow it. Using zero after A is the same as using E.

- Next, enter the first number of the problem.
- Then, use an operation sign.
- And finally, enter the second number of the problem, with or without an A or an E. (Each A must be followed by a number.) If no prefix is given for the second number, the specification for the first number (A or E) applies to the entire problem.
- Leave spaces between each part of the problem, and press Return/Enter when it is complete.

After the problem has been entered, the user is asked "Another answer?" Press Y (yes) to see a new answer displayed. You may request an unlimited number of answers; or if you answer N (no), the exact answer is displayed and you may enter a new problem.

Examples

Example 1

Attendance at a sports event was 16,000, rounded to the nearest 1,000. Each person paid $12.50 exactly for their seat. Calculate the gate receipts.

The problem would be entered as

```
A 1000 16000 * E 12.50
```

"A 1000" indicates the first number is accurate to the nearest 1,000, and E indicates the second number is exact. The computer generates samples of possible gate receipts.

```
16000 * 12.5 = 200000.0
15800 * 12.5 = 197500.0
16100 * 12.5 = 201250.0
15900 * 12.5 = 198750.0
16000 * 12.5 = 200000.0
15700 * 12.5 = 196250.0
16100 * 12.5 = 201250.0
16300 * 12.5 = 203750.0
16100 * 12.5 = 201250.0
15700 * 12.5 = 196250.0
16100 * 12.5 = 201250.0
15700 * 12.5 = 196250.0
15800 * 12.5 = 197500.0
15800 * 12.5 = 197500.0
16300 * 12.5 = 203750.0
15700 * 12.5 = 196250.0
```

Example 2

What is the area of a rectangle that is 21 cm x 24 cm where the measurements are accurate to the nearest centimeter?

```
21.4 * 24.5 = 524.3
21.0 * 23.5 = 493.5
20.7 * 24.2 = 500.94
21.4 * 24.4 = 522.16
20.7 * 24.1 = 498.87
21.1 * 23.7 = 500.07
20.8 * 23.5 = 488.8
21.1 * 24.1 = 508.51
21.5 * 23.7 = 509.55
21.0 * 24.4 = 512.4
21.5 * 24.3 = 522.45
20.9 * 23.6 = 493.24
20.5 * 24.5 = 502.25
21.0 * 24.3 = 510.3
```

Notice the hundreds digit is nearly stable and that the tens digit is the first digit to change. This suggests that the answer should not be expressed to more than two-digit accuracy. This reinforces the preceding information that indicates your answer can be no more accurate than the least accurate number that went into the problem.

Thus, the exact answer of 504 should be rounded to two-digit accuracy 500 (dropping the 4).

Example 3

The attendance at an event was about 13,000 (rounded to the nearest 1,000) with each person paying exactly $13.75. Estimate the gate receipts.

```
13100 * 13.75 = 180125.0
12600 * 13.75 = 173250.0
13200 * 13.75 = 181500.0
12600 * 13.75 = 173250.0
13400 * 13.75 = 184250.0
12500 * 13.75 = 171875.0
13500 * 13.75 = 185625.0
13200 * 13.75 = 181500.0
13400 * 13.75 = 184250.0
13300 * 13.75 = 182875.0
12600 * 13.75 = 173250.0
13300 * 13.75 = 182875.0
```

The exact calculation is 13,000 x 13.75 = $178,750.

Notice the stability of 13.75 but that the attendance is stable in the first digit (two-digit accuracy). The answer is no more stable than the attendance, i.e., two-digit accuracy, and the answer $178,750 should be rounded to $180,000.

Supplementary Information

Error

A measurement accurate to one unit can be up to a half unit bigger or a half unit smaller than the value listed.

- 6 accurate to the nearest whole number will fall between 5.5 and 6.5; that is 6 can be in error by as much as ±0.5.
- 23.5 accurate to the nearest 0.1 will fall between 23.45 and 23.55; that is, 23.5 can be in error by as much as ±0.05.
- 23,000 accurate to the nearest 1,000 will fall between 22,500 and 23,500; that is, 23,000 can be in error by as much as ±500.
- 0.035 accurate to nearest 0.001 will fall between 0.0345 and 0.0355; that is, 0.035 can be in error by as much as ±0.0005.

Significant Digits and Digit Accuracy

In the preceding four examples

- 6 contains one significant digit (one-digit accuracy)
- 23.5 contains three significant digits (three-digit accuracy)
- 23,000 contains two significant digits (two-digit accuracy)
- 0.035 contains two significant digits (two-digit accuracy)

In the last example, zeros to the left of a non-zero number are not counted as significant digits.

Form of Answers

An answer should be given no more accurately than the least accurate number that went into the calculation. For example, 14,000 fans (rounded to the nearest 1,000) paid exactly $13.25 each. Calculate the gate receipts.

The exact multiplication gives 14,000 x 13.25 = 185,500, but 14,000 is accurate to nearest 1,000, i.e., two significant digits/two-digit accuracy. Thus, 185,500 should be written with two-digit accuracy, i.e., $190,000.

Rounding

Expressing answers to the least accurate input is done by rounding the answer to the required accuracy.

Rules for rounding:

If the digit dropped is 5 or more, increase preceding digit, e.g., 185,500 is rounded to 190,000.

If digit dropped is 4 or less, leave preceding digit, e.g., 184,920 is rounded to 180,000

If digit dropped is 5 (followed by zeros), increase preceding digit if it is odd, leave it unchanged if it is even, e.g., 185,000 is rounded to 180,000 while 175,000 is rounded to 180,000.

Activities

Activity 1: Stable Numbers/Expressing Answers to Appropriate Accuracy

Enter sum, difference, product, or quotient problems that involve the use of one or more approximate numbers. Study a set of possible answers. Notice the digits that never change, the first digit that changes, and the rest of the digits that vary widely.

Write an analysis of your results similar to those given in Examples 3 and 4.

Activity 2: Largest/Smallest Answers

Enter sum, difference, product, or quotient problems involving approximate numbers. Generate a set of answers. Use them to establish largest and smallest possible answers.

Appendix A
Summary of *LogoWriter* Keys for the Apple IIe/IIc

General Purpose Keys

Flip	Apple-F
Up	Apple-U
Down	Apple-D
Quit, leave page	Esc
Stop	Apple-S
Help	Apple-0

Word-Processing Keys

Select	Apple-1
Cut	Apple-2
Copy	Apple-3
Paste	Apple-4
Erase to End of Line	Apple-6
Next Screen	Apple —>
Previous Screen	Apple <—
Top of Page	Apple-Up Arrow
Bottom of Page	Apple-Down Arrow
Beginning of Line	Apple-B
End of Line	Apple-E
Open a Line	Apple-O
Delete Right	Control-D

Shapes Page Keys

Quit, leave page	Esc
Flip	Apple-F

On the flip side of the page only:

Next Screen (Next Shape)	Apple —>
Previous Screen (Previous Shape)	Apple <—
Up, Down, Left, Right	Arrow keys
Cut	Apple-2
Copy	Apple-3
Paste	Apple-4
Make or Erase Block	Space Bar

Graphics Keys

Turtle-Move	Apple-9
Label	Apple-8
Leave Label or Turtle-Move	Esc

Contents Keys

Top of Page	Apple-Up Arrow
Bottom of Page	Apple-Down Arrow
Remove a Page (Erase to End of Line)	Apple-6

Summary of the *LogoWriter* Keys for the IBM

General Purpose Keys

Flip	Control-F
Up	Control-U
Down	Control-D
Quit, leave page	Esc
Stop	Control-Break
Help	Fn-0

Word-Processing Keys

Select	Fn-1
Cut	Fn-2
Copy	Fn-3
Paste	Fn-4
Erase to End of Line	Fn-6
Next Screen	PgDn
Previous Screen	PgUp
Top of Page	Home
Bottom of Page	End
Beginning of Line	Control <—
End of Line	Control —>
Open a Line	Insert

Shapes Page Keys

Quit, leave page	Esc
Flip	Control-F

On the flip side of the page only:

Next Screen (Next Shape)	PgDn
Previous Screen (Previous Shape)	PgUp
Up, Down, Left, Right	Arrow keys
Cut	Fn-2
Copy	Fn-3
Paste	Fn-4
Make or Erase Block	Space Bar

Graphics Keys

Turtle-Move	Fn-9
Label	Fn-8
Leave Label or Turtle-Move	Esc

Contents Keys

Top of Page	Home
Bottom of Page	End
Remove a Page (Erase to End of Line)	Fn-6

Summary of *LogoWriter* Keys for the Macintosh

General Purpose Keys

Flip	⌘-F
Up	⌘-U
Down.	⌘-D
Quit, leave page	Esc, Clear, or ⌘-Shift
Stop	⌘-.

Word-Processing Keys

Select	⌘-1
Cut	⌘-2 or ⌘-X
Copy	⌘-3 or ⌘-C
Paste	⌘-4 or ⌘-V
Erase to End of Line	⌘-6
Next Screen	⌘—>
Previous Screen	⌘<—
Top of Page	⌘-Up Arrow
Bottom of Page	⌘-Down Arrow
Beginning of Line	⌘-B
End of Line	⌘-E
Open a Line	⌘-O

Shapes Page Keys

Quit, leave page	Esc
Flip	⌘-F

On the flip side of the page only:

Cut	⌘-2 or ⌘-X
Copy	⌘-3 or ⌘-C
Paste	⌘-4 or ⌘-V

Graphics Keys

Turtle-Move	⌘-9
Label	⌘-8
Leave Label or Turtle-Move	Esc

Appendix B
Quick Reference

LogoWriter Primitives and Special Words

* Primitive is a reporter (operator).
\# Primitive is either a command or a reporter.

Screen
- CC—Clear Command center
- CG—Clear Graphics
- CP—Clear Page
- CT—Clear Text

Scrapbook
- CLEARTOOLS
- CONTENTS
- DOS (IBM only)
- ERPAGE *pagename*—ERase Page
- FLIP
- * FRONT?
- GETPAGE (GP) *pagename*
- GETSHAPES *pagename* (Mac Only)
- GETSOMESHAPES *pagename list* (Mac Only)
- GETTOOLS *pagename*
- LEAVEPAGE
- LOAD *pagename*
- LOCK (Mac only)
- NAMEPAGE (NP) *pagename*
- NEWPAGE
- * PAGELIST
- RESTORE
- SAVEPAGE
- SHAPES
- * TOOLLIST
- UNDO (IBM and Apple only)
- UNLOCK

Workspace
- RECYCLE
- * SPACE

Timing
- CLOCK (Mac Only)
- RESET (Mac Only)
- TIMER (Mac Only)
- WAIT *number*

Sound
- ERSOUND *name* (Mac Only)
- PLAY *name* (Mac Only)
- RECORD *name number* (Mac Only)
- SOUNDLIST (Mac Only)
- TONE *frequency time*

Input/Output
- * BUTTON? *button number* (Mac—no input)
- CLEARCOM (Mac Only)
- * KEY?
- PADDLE *number* (IBM and Apple only)
- * READCHAR (Mac only)
- * READLIST (RL)
- * READLISTCC (RLCC)
- RECEIVECHAR (RCCC)
- SEND *word / list* (Mac only)
- SETBAND *number* (Mac only)
- SETCF *word1 word2* (Mac only)

Assigning
- CLEARNAME *word / list*
- CLEARNAMES
- MAKE *name word / list*
- NAME *word / list name*
- * NAME? *word*
- PRINTNAMES
- SHOWNAMES
- THING *names*

Printer Commands
- DSPACE—Double SPACE (IBM and Apple only)
- PRINTSCREEN
- PRINTTEXT
- PRINTTEXT80 (IBM and Apple only)
- SSPACE—Single SPACE (IBM and Apple only)

Special Words

END
FALSE
HELP *pagename* (Mac only)
STARTUP
TO
TRUE

System Modifying Primitives (IBM/Apple)

.BLOAD *name/pathname address*
.BSAVE *name/pathname address length*
.CALL *address*
.DEPOSIT *address byte*
* .EXAMINE *address*

Flow of Control/Logic

* AND *true/false1 true/false2*
CAREFULLY *list1 list2*
ERRORMESSAGE (Mac Only)
ERRORNUMBER (Mac Only)
* IF *true/false list to run*
# IFELSE *true/false list.to.run1 list.to.run2*
LOCAL *word/list* (Mac Only)
* NOT *true/false*
* OR *true/false1 true/false2*
OUTPUT (OP) *word/list*
REPEAT *number list.to.run*
RUN *list.to.run*
STOP
STOPALL

Math (Note: all are reporters)

\+ - * / (Mac only)
> < =
<> <= >= \ ^
ABS *number* (Mac only)
ARCTAN *number*
COS *degrees*
DIFFERENCE *number1 number2* (Mac Only)
E (Mac Only)
EXP *number* (Mac Only)
GREATER? *number1 number2* (Mac Only)
INT *number*
LESS? *number1 number2* (Mac Only)
LN *number* (Mac Only)
LOG *number1 number2* (Mac Only)
PI (Mac Only)
POWER *number1 number2* (Mac Only)
PRODUCT *number1 number2* (Mac Only)
QUOTIENT *number1 number2* (Mac Only)
RERANDOM (Mac Only)
RANDOM *number*
ROUND *number*
SETNF *number* (Mac Only)
SETPOINT (Mac Only)
SETCOMMA (Mac Only)
SIN *degrees*
SQRT *number*
SUM *number1 number2* (Mac Only)
TAN *number*

Events

CLEAREVENTS
PRINTEVENTS (Mac Only)
SHOWEVENTS (Mac Only)
WHEN *letter list.to.run*

Graphics

* ALL
# ASK *turtle/turtle.list list.to.run*
BACK (BK) *number*
* BG
CHANGECOLOR *number list of three numbers* (GS)
* CHARUNDER - CHARacter UNDER
CLEAN
* COLOR
* COLORUNDER
* COLORVALUE *number* (GS)
* CURSORPOS
* DISTANCE *list of two numbers* (GS/IBM/Mac)
EACH *list.to.run*
FASTTURTLE (GS/Mac)
FILL
FORWARD (FD) *number*
HEADING
HOME
HT—Hide Turtle
LABEL *word/list*
LEFT (LT) *number*
MOUSEPOS (Mac Only)
PD—Pen Down
PE—Pen Erase
* POS
PU—Pen Up
PX—Pen Reverse
RESETCOLORS (GS)
RG—Reset Graphics
RIGHT (RT) *number*
SETBG *number*
SETC *number*
SETH *number*
SETPOS *[x y]*

SETSH *number*
SETX *number*
SETY *number*
SHADE
* SHAPE
SLOWTURTLE (GS/Mac)
ST—Show Turtle
STAMP
TELL *turtle / turtle.list*
TOUCHING? (Mac Only)
* TOWARDS *list*
* WHO
WINDOW
WRAP
XCOR
YCOR

Text Editing/Words and Lists

* ASCII *char*
BOTTOM
* BUTFIRST (BF) *word / list*
* BUTLAST (BL) *word / list*
CB—Cursor Back
CD—Cursor Down
CF—Cursor Forward
* CHAR
* CLIPBOARD
COPY
* COUNT
CU—Cursor Up
CURSORCHAR
CUT
DELETE
* EMPTY? *word / list*
EOL
* EQUAL? *word / list1 word / list2*
* FIRST *word / list*
* FOUND?
* FPUT *word / list list*
* IDENTICAL? *word / list1 word / list2*
INSERT *word / list*
* ITEM *number word / list*
* LAST *word / list*
* LIST *word / list1 word / list2*
* LIST? *word / list*
* LPUT *word / list list*
* MEMBER? *word / list1 word / list2*
NEXTSCREEN
* NUMBER?
PARSE *word*
PASTE
PRESCREEN
PRINT (PR) *word / list*
REPLACE *word1 word2*
SEARCH *word*
SELECT
* SELECTED
* SENTENCE (SE) *word / list1 word / list2*
SETEXTPOS *number*
SETTC *number* (GS)
SHOW *word / list*
SOL—Start Of Line
TAB
* TC (GS)
* TEXTLEN
* TEXTPOS
TOP3
TYPE *word / list*
UNSELECT
* WORD *word1 word2*
* WORD? *word / list*

Disk (Apple or IBM)

* DISK
SETDISK *letter*

ProDos Primitives

BYE
COPYFILE *name / pathname1 name / pathname2*
CREATEDIR *pathname*
* DIRECTORIES
DISK (Mac only)
ERASEFILE *name / pathname*
* FILELIST
LOADPIC *name / pathname*
LOADTEXT *name / pathname*
* ONLINE
* PREFIX
RENAME *name / pathname1 name / pathname2*
SAVEPIC *name / pathname*
SAVETEXT *name / path*
SETDISK *word*
SETPREFIX *pathname*
SETSLOT
* SLOT
* .VERSION

IBM DOS Primitives

CHDIR *name / pathname*
COPYFILE *name / pathname1 name / pathname2*
* CURRENTDIR
* DIRECTORIES
DISK
DOS

ERASEFILE *name / pathname*
* FILELIST
LOADPIC *name / pathname*
LOADTEXT *name / pathname*
MKDIR *pathname*
RENAME *name / pathname1 name / pathname2*
RMDIR
SAVEPIC *name / pathname*
SAVETEXT *name / pathname*
SETDISK *word*
* .VERSION

Macintosh Primitives

COPYFILE *name / pathname1 name / pathname2*
CREATEDIR *pathname*
* DIRECTIONS
* DISKSPACE
ERASEFILE *filename*
* FILELIST
LOADPIC *filename / pagename*
LOADTEXT *filename / pagename*
* ONLINE
PAGE
* PREFIX
QUIT
RENAME *name / pathname1 name / pathname2*
RMDIR *name*
SAVEPIC *name / pathname*
SAVETEXT *filename*
.VERSION

Appendix C
Additional Primitives for the Macintosh

Math Primitives

number/ \number
\ is the equivalent of REMAINDER

ABS *number*
ABS reports the absolute value of its input.

DIFFERENCE *number1 number2*
DIFFERENCE is the prefix form of the subtraction sign (-). It takes two numbers as input and reports the result of subtracting the second input from the first one.

E
Reports the value of the transcendental number e.

EXP *number*
EXP takes one number as input. It reports the number e raised to the power of the input to EXP. This is the inverse of LN.

LN *number*
LN reports the natural logarithm of its input. This is the inverse of EXP.

LOG *number (or number1 number2)*
LOG reports the logarithm of its input in base 10.

PI
Reports the value of π.

POWER *number1 number2*
Reports the value of the first input raised to the second input.

PRODUCT *number1 number2*
This is the prefix form of the multiplication sign (*). It reports the product of its two inputs.

QUOTIENT *number1 number2*
QUOTIENT reports the result of dividing the first input by the second input. Division by zero gives an error. This is the prefix form of the division sign (/).

SETNF *number*
This primitive takes one input and sets the number of digits displayed after the decimal point. The default is for *LogoWriter* to display 4 digits. SETNF does not affect the precision of Macintosh *LogoWriter*. It always uses 16 digits for

computations. Macintosh *LogoWriter* can also display numbers in scientific notation. For example 1.0E10 means 10^{10}.

SETPOINT
Causes LogoWriter to use a decimal to separate the integer part from the fractional part of a number.

SETCOMMA
Causes LogoWriter to use a comma to separate the integer part from the fractional part of a number.

SUM *number1 number2*
This is the prefix form of the addition sign (+). It reports the sum of the two input numbers.

TAN *number*
TAN reports the tangent of its input in degrees.

Flow of Control and Logic

CAREFULLY *list1 list2*
CAREFULLY takes two lists as inputs. The first input is a list of instructions that is run. If there is an error while this list is running, the second list is run. If there is no error in the first list, the second is ignored and ERRORNUMBER is set to 0 while ERRORMESSAGE is an empty word.

ERRORMESSAGE
This reporter returns the most recent error message.

ERRORNUMBER
This reporter returns the number of the most recent error message.

-H
Pressing this key combination causes the current procedure to pause. Pressing any key causes it to begin again.

Time

CLOCK
This reporter returns a list containing the date and the time in the format [10/19/89 4:30:55 PM]

RESETT
Resets the timer to 0.

TIMER
This primitive reports the duration, in 60ths of a second, since the last RESETT command.

Help

HELP
The HELP primitive allows you to create your own Help page. It takes one input, the name of a page. The page can be looked at but not changed.

Help Menu
Under the Apple Menu at the left edge of the menu bar are two choices for help. The "Help Page..." option gets a page named help. The "Help Primitives..." displays a list of all the primitives in Macintosh *LogoWriter* in alphabetical order. Clicking on one of the primitives in the list causes a description of that primitive to appear.

Sound

ERSOUND *sound*
This command takes the name of a sound resource as input and erases it.

PLAY *sound*
This command takes one input and plays the named sound resource.

RECORD *sound duration*
This command takes two inputs, a name and a number. The first input is the name to be used to save a recorded sound. The second is the number of seconds to be recorded. This command works with Macintosh models with built in microphones.

SOUNDLIST
Reports the list of current sound resources.

Communication

CLEAR COM
Clears the communication line.

RECEIVECHAR, RECC
This reporter returns the character being received through the communication channel. If no character is being received, LogoWriter waits for a character.

SEND *word/list*
This command sends a word or a list through the communication line. It does not send a carriage return following the input.

SETBAUD *number*
This command takes a number as input. This number must be one of the following baud rates: 300, 1200, 2400, 4800, 9600, 19200. The default value is 4800.

SETCF
This command takes two inputs and sets the communication format. The first input is the category; the second input is the value. Here are the possible values:

Miscellaneous

BUTTON?
Reports true if mouse button has been clicked.

MOUSE POS
Returns the position of the mouse in turtle coordinates.

PRIMITIVES
This reports a list of all of the primitives in LogoWriter.

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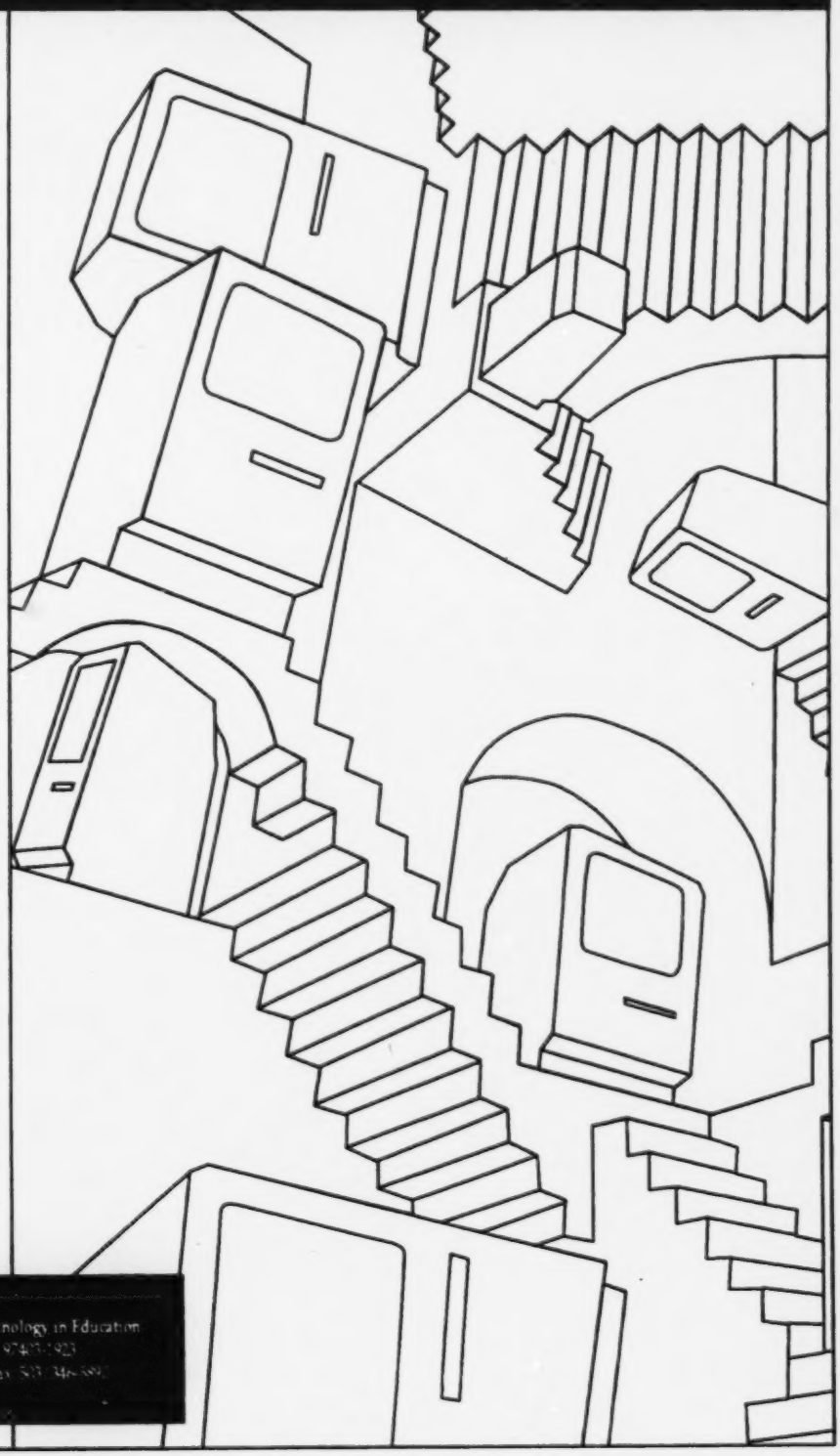

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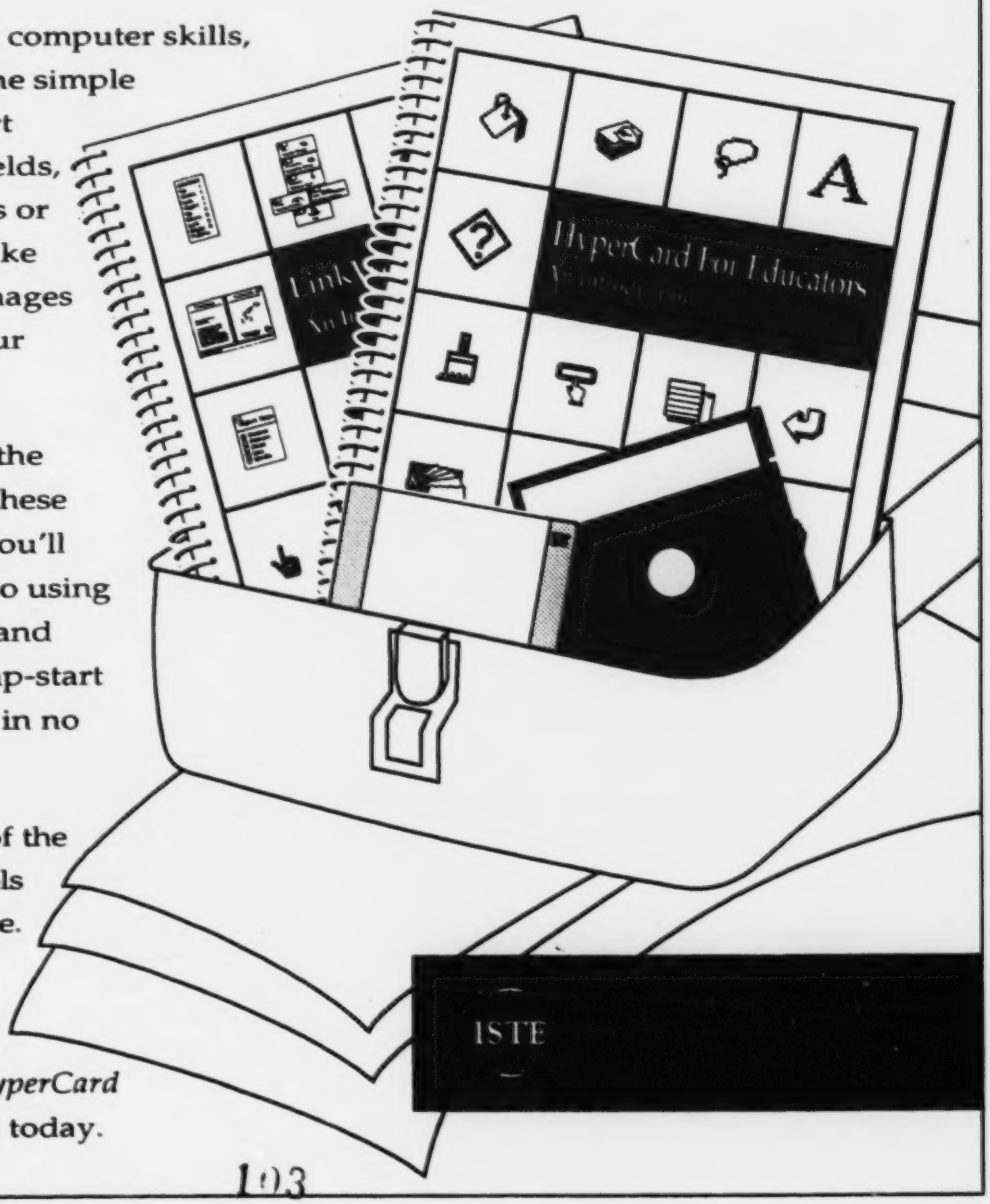
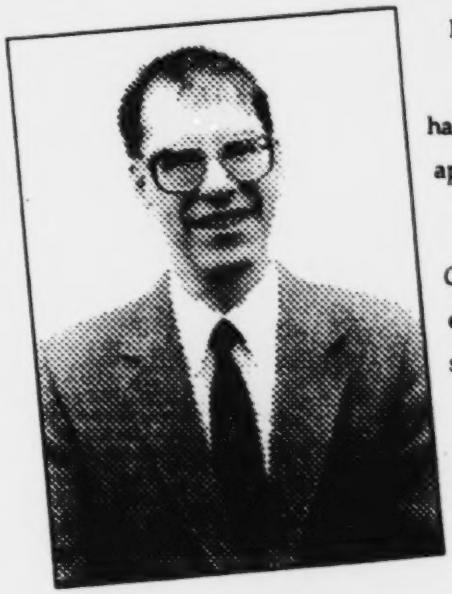


Dave Moursund knows...



ISTE Executive Officer Dave Moursund is dedicated to improving education.

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In recent years, Dave has focused much of his writing efforts on problem solving and on staff development. Some of Dave's other books also available from ISTE include *Problem-Solving Models for Computer Literacy, LogoWriter for Educators: A Problem Solving Approach, Logo PLUS for Educators: A Problem Solving Approach* (co-authored with Sharon Yoder), and *Effective Inservice for Integrating Computer-as-Tool into the Curriculum.*

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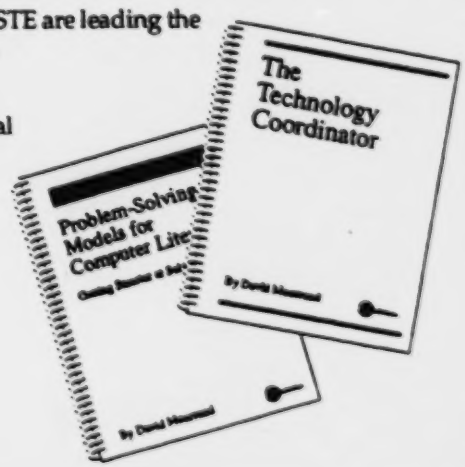

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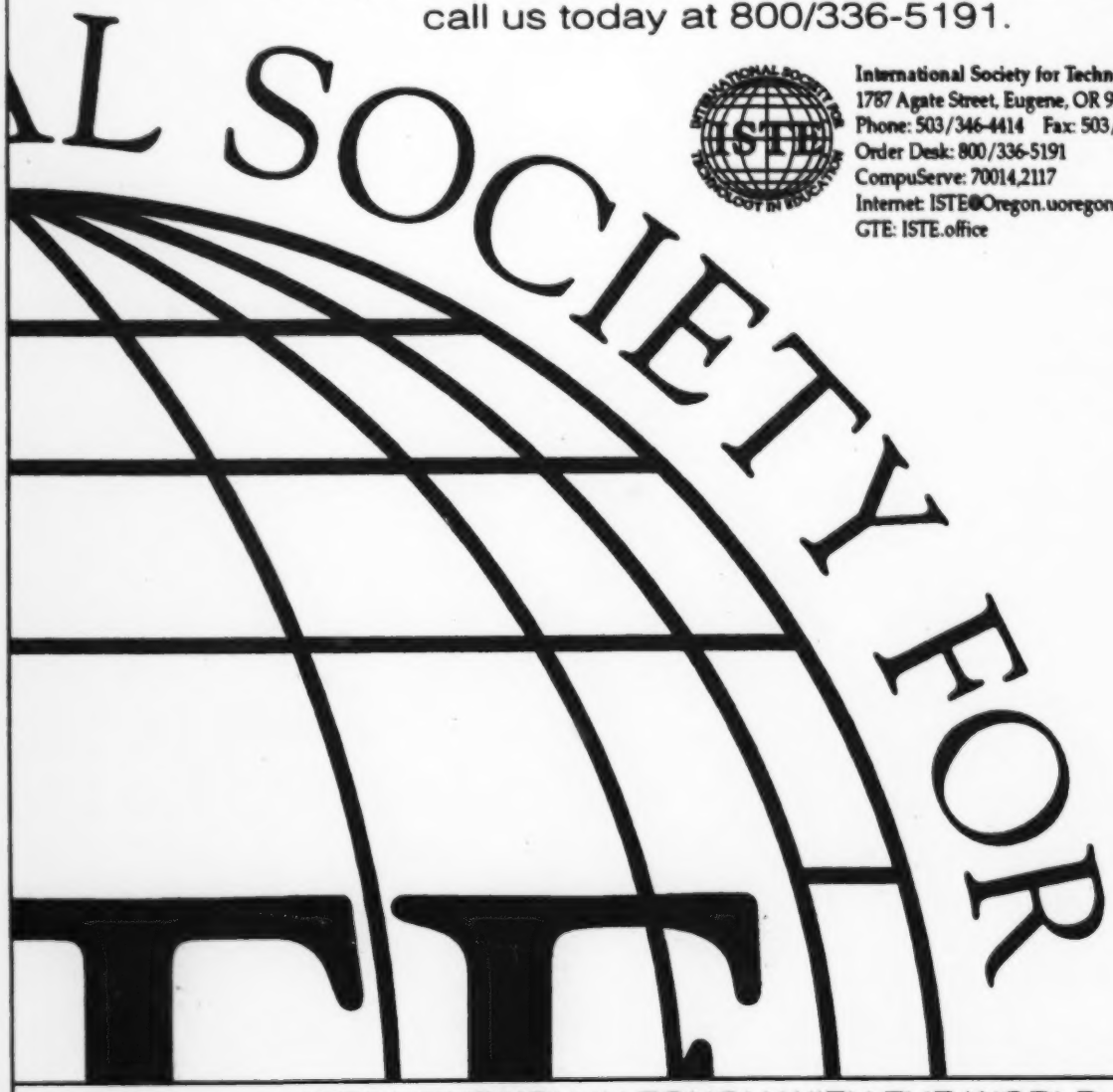

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